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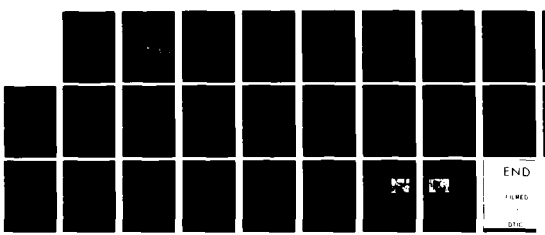

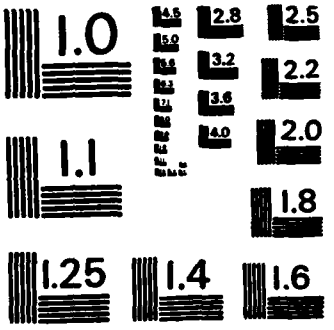

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This is a monthly publication presenting brief articles concerning recent developments in European Scientific Research. It is hoped that these articles (which do not constitute part of the Scientific Literature) may prove of value to American scientists by calling attention to current developments and to institutions and individuals engaged in these scientific efforts.

The articles are written primarily by members of the staff of ONRL and occasionally articles are prepared by, or in cooperation with members of the

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scientific staffs of the United States Air Force European Office of Aerospace Research and Development and the United States Army Research and Standardization Group. Articles are also contributed by visiting Stateside scientists.

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OFFICE OF NAVAL RESEARCH
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edited by Donald R. Barr and Don J. Peters

31 August 1982 Volume 36, No. 8

BEHAVIORAL SCIENCES

ELECTRONICS

MATERIAL SCIENCES

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XI International Symposium on Mathematical Programming, Bonn, FRG, 23-27 August 1982.

4th Europhysical Topical Conference on Lattice Defects in Ionic Crystals, Dublin, Ireland, 30 August - 3 September 1982.

MOLEC IV - European Study Conference on Low Energy Collisions, "Het Vennenbos," Eindhoven, Netherlands, 6-10 September 1982.

2nd International Workshop on "Ion Formation from Organic Solids II," Münster, Germany, 7-10 September 1982.

4th International Symposium on Gas Flow and Chemical Lasers, Stresa, Italy, 13-17 September 1982.

14th Europhysics Conference on Macromolecular Physics, "Polymer Crystals: Structure & Morphology," Vilafranca del Penedes, Spain, 21-24 September 1982.

EUROPEAN VISITORS TO THE US SUPPORTED BY ONR LONDON

Visitor	Affiliation	Navy Lab./Org. to be Visited
Dr. E. Augstein	Max-Planck Inst. for Meteorology Hamburg, W. Germany	NEPRF/NPS Monterey (23-24 August 1982) Polar Science Center APL-Univ. of Wash. (25-27 August 1982)
Christopher Brand	Univ. of Edinburgh Psychology Dept.	Navy Personnel Research & Dev. Lab., San Diego (June-August 1982)
Dr. Alon Gany	Technion, Haifa, Israel	NWC, China Lake (15 September 1982) NPS, Monterey (17 September 1982)
Dr. Avraham Gover	School of Engineering, Tel-Aviv Univ., Israel	PGS, Monterey ONR/NRL (July-August 1982)
Prof. N.S. Kopeika	Ben-Gurion Univ. of the Negev, Israel	NOSC, San Diego (August 1982)
Dr. P. Taylor	IOS Wormley, Godalming, Surrey	NPS/NEPRF Monterey (23 August 1982) Polar Science Center APL-Univ. of Wash. (25-27 August 1982)

BEHAVIORAL SCIENCES

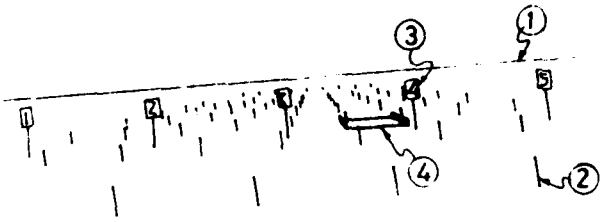
OBSTACLE AVOIDANCE IN LOW-ALTITUDE FLIGHT

When a crop-duster pilot crashes into something like a pole or power line, it often happens that the offending obstacle was "clearly visible"; at least, the object could be easily seen by an ordinary observer, and indeed it may have been noticed and specifically acted upon by the pilot just a short time before. There are various ways to interpret these momentary and occasionally disastrous lapses by pilots. One plausible explanation of the ineffective behavior is that, when a pilot is under high workload, there are visual field areas where detectability of objects is reduced; these reductions are significant enough, after many repetitions of the basic flight task, to cause missed perceptions of threatening obstacles. Recent Israeli work on this problem is notable both for its substantive findings and for the inexpensive simulator that was employed. The research was reported last June by A.J. Grunwald, at the 2nd European "Annual Manual" (Conference on Decision Making and Manual Control) in Bonn, Germany. Grunwald is at the Department of Aeronautical Engineering, the Technion, Haifa.

Previous work at the Technion and elsewhere had shown that the central visual area does indeed tend to narrow down with an increase in workload. But it was also believed that the pilot could be unburdened by such means as augmenting predictor symbols on a heads-up display. This would leave more attentional resources available for obstacle detection. The research approach, then, was to determine the effectiveness of detection with and without augmentation. A special simulator served as the test environment.

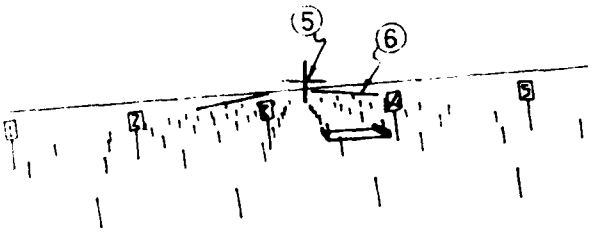
Figure 1 shows the unaugmented representation of an agricultural field as it appears on the simulator CRT. Vegetation is simulated by straight lines or "stalks" that are a nominal 8 ft high; these stalks move back under the plane as flight proceeds. As Grunwald's movie of the display indicated, all the motions are reasonably veridical. The vegetation is arranged in five straight rows or lanes; a boxlike lane marker appears in one of the five lanes. The pilot's basic task is to fly a straight path down the row designated by the lane marker. In the simulator setup, the lane marker can be programmed to appear in a different lane every few seconds.

In the simulator configuration shown in Figure 2, there are augmentation cues for the pilot. The two altitude reference bars are designed to simplify altitude control and are displayed so that when the pilot is at the correct altitude (20 ft) the bars are aligned parallel with the horizon. When the aircraft is slightly high, as in Figure 2, the bars are below the horizon; when the aircraft is too low, the bars are above the horizon, pointing upwards. Thus the altitude augmenting cue is a "fly-to" display; the pilot should always fly to the bar until it is on the horizon.



1 Horizon
2 Vegetation
3 Field Flags
4 Lane Marker

Fig. 1. Unaugmented Visual Field



5 Predicator or Velocity Vector Symbol
6 Altitude Reference Bars

Fig. 2. Augmented Visual Field

Two kinds of velocity augmentation were tried. In the "plain" velocity presentation, the lateral and vertical displacement of the displayed velocity symbol were direct functions of slip angle and angle of attack. For a "predictor" presentation, the lateral and vertical path angle rates enter into the display computation. As an example, the "predictor"

calculation for lateral velocity stems from the following formula:

predictor symbol
displacement $= \beta + 0.5\,(D/V)\dot{\gamma}$,
where β = slip angle
D = standard distance
V = velocity
$\dot{\gamma}$ = lateral path-angle rate.

In effect, the unburdened pilot can employ all these augmentation displays as "fly-to" items. When the lane marker is suddenly switched to a new lane, augmented flight would be expected to be easier, with improved detection of secondary items in the field. Figure 3 shows a perspective view of the geometry.

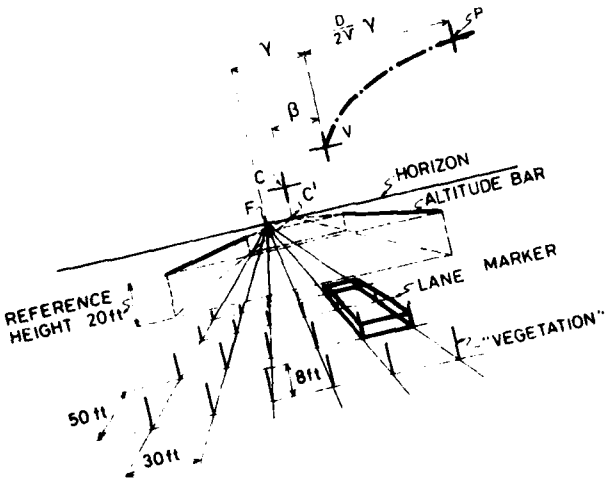


Fig. 3 Geometry of Display Symbology; Perspective View.

Given the simulator setup just described, the experimenters went on to introduce secondary tasks into the flight regime. One scheme required subjects to notice a two-digit number when it appeared on the screen and to push a button if the second digit was larger than the first digit. The experiment was under automatic "adaptive" control: if the subject reacted correctly, the rate of appearance of new numbers was increased.

Another experimental extension used a pattern of 16 small hexagons; sometimes, one of the hexagons was defective, with one of its sides missing. The pilot was told to search for the defective figure. When a defective hexagon was observed, the subject was to press an indicator button. In both the two-digit number and the hexagon tasks, stimuli were automatically displayed at different locations around the field.

The first major result was that augmentation improved general flight behavior; both predictor and plain velocity vector symbols resulted in much less pitch-and-roll activity. Another result was that roll-and-pitch actions increased noticeably as the number stimuli were presented further out from the center of the visual field.

When hexagon detection was the secondary task, the high-probability-of-detection zones were indeed much wider for the augmented states, with the predictor symbols producing the best performance. Also, the detection likelihoods were higher and the reaction times were shorter for the upper area of the visual field than for the bottom area. Grunwald thought that this might be due to the fast-moving vegetation in the bottom area of the display. A special difficulty occurred when the target hexagons were near the horizon and altitude reference bars, however; apparently, the clutter of lines in that area caused significant confusion and loss of detectability. The practical point learned was that the computed augmentation cues should be kept as separate as possible from the target cues.

As the investigators realize, the work may not be generalizable to other situations; an effective magnification of 0.42 was used, there were only a few subjects, and the equations of motion from an S-2R aircraft were the only ones investigated. However, the strong behavioral effects of augmentation and secondary task difficulty argue that the setup is a good research vehicle for low-altitude flight problems.

An interesting aspect of the research was the relatively low cost of the simulator used, in which the total investment was only a few thousand dollars. As the reviews of Roscoe, Orlansky, and others have shown, simulators can often cost millions of dollars. Many American researchers might wish that Grunwald's display had a little more realism, that there could be a greater variety of terrain shown, or that the task could be varied from a straight-path lane-switching regime. These Israeli studies show, however, that clever task and augmentation research can be accomplished without vast simulator facilities.

N.A. Bond, Jr.
ONR London

ELECTRONICS

CREATING BETTER SOLID STATE ENERGY SWITCHING DEVICES AT IMPERIAL COLLEGE

The UK Imperial College of Science and Technology was established by Royal Charter in 1907 and was comprised of the Royal School of Mines, the Royal College of Science, and the Central Technical College of the City and Guilds of London Institute. It became a campus of the University of London the following year.

Today the academic staff of the Imperial College totals over 700 including 2 Nobel laureates, 38 fellows of the Royal Society, 90 full professors, and 95 associate professors. Of over 4,500 students, nearly half are studying engineering. Over 30% are postgraduates, and 250 PhD degrees are awarded each year. In the School of Electrical Engineering, 75% of those attending are overseas students who do not hold British passports! Throughout the college the ratio of overseas students is lower but foreign registrants still account for over a third of the postgraduates.

Prof. B.D. Williams of the Electrical Engineering Department took his PhD from Cambridge and has been at Imperial College for 3 years. He has established a program directed toward the creation of more efficient solid-state high-voltage high-power energy-switching devices. His work takes two basic approaches. The first uses conventional semiconductor thyristor switches. In conventional approaches to commutating these switches, a sizable amount of power is dissipated in the commutating circuits. Not only is extra bulk required to dissipate the heat, but such procedures are wasteful of energy. Using novel circuit techniques, Williams has developed an approach to direct the current of the commutating circuit into the intended load rather than dissipating it as heat. In this method, the commutating circuit losses are but 5% of those experienced by conventional approaches. The techniques developed here are applicable to aircraft power supplies inter alia.

The second approach Williams follows seeks a much less complex solution to more efficient power switching. For this effort a new semiconductor thyristor switch has been designed that incorporates an efficient control gate that not only turns the device on (as do conventional thyristors) but also is capable of turning the device off while it is conducting current. Such a structure virtually eliminates the complex commutating circuitry required by conventional switching power supplies. With the elimination of such circuitry goes the wasted energy associated with the commutator. The semiconductor device designed and patented by Williams is shown in Figure 1.

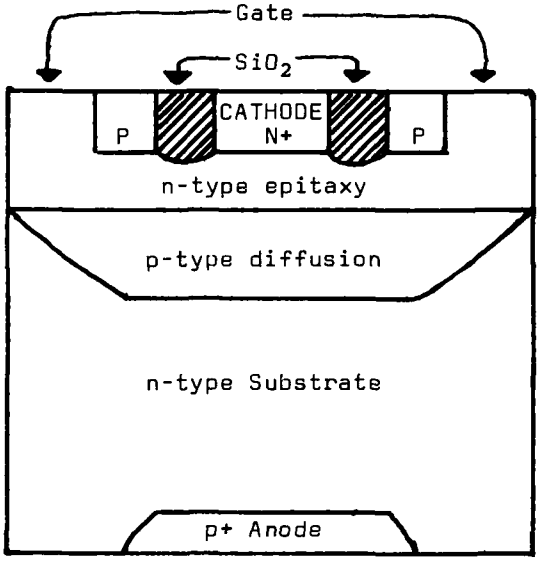


Fig. 1 Gate Turnoff Thyristor

It is the equivalent of a four-layer device and requires a combination of all of the processing techniques currently used in the semiconductor art for its fabrication. This requirement for a combination of processing techniques has stymied the development of the device, as most semiconductor device manufacturers are capable of one or two basic processing techniques but can seldom accomplish three. The device in question requires diffusion, epitaxy, and ion implantations. The substrate, shown on the bottom in Figure 1, is n-type material with a donor concentration of $1x10^{16}/cm^3$. A p+ anode contact is diffused into the bottom of the substrate. Acceptors are diffused into the top of the substrate in such a manner that their concentration at the substrate surface is $1x10^{18}/cm^3$ and tapers to $1x10^{16}/cm^3$ near the electrical interface with the n type substrate. Over the top substrate surface an n type epitaxial layer is deposited with a donor concentration near $1x10^{17}/cm^3$. Care must be taken that the epitaxial layer is of uniform thickness over the entire substrate as the subsequent ion implantation depth of acceptors will control the thickness of the "base" region of the control transistor. The n+ thyristor cathode and the p type collector regions of the auxiliary gate control transistors are ion-implanted into the surface of the epitaxial layer. Metallization interconnects the n+ cathode and the p-type collector regions after they are oxide isolated. Contact for the control gate (transistor base) is to the remaining surface of the n-type epitaxial layer. Control gate turnoff operation is as follows: Consider first the on state of the device wherein electrons are being injected from the n+ cathode

through the diffused p region and thence through the depleted n-type substrate from whence they are collected by the p+ anode. A negative (forward) bias applied to the control gate causes the control transistor to become forward biased. The control transistor (being annularly concentric around the main path of charge carrier flow of the thyristor switch) in its on state provides a lower resistance path than does the central core through the n type epitaxy region. As such, the central core injection ceases, and when forward bias is removed from the gate control transistor all current stops. The entire switching action is said to take but a microsecond! As energy is dissipated only during the switching period and as this time is about 100 times shorter than conventional commutating times, the device is very efficient. During the switching period, the bulk of the current through the switching transistor is delivered to the load.

Most of the work on the device has involved research on the theory of operation of the device and development of a computerized model for its operation. As the combination of semiconductor processing techniques required for operation of the device is lacking at Imperial College, Williams is searching for an industrial partner interested in a cooperative venture. Predictions for the device include a stand-off voltage up to 7,000 volts (derived from the low n-type doping concentration of the substrate) and several thousand amperes (owing to the large area of the device). A penalty of slow switching operation normally associated with large area devices does not accrue because of the comparatively small area of the turnoff transistor. The devices have application to high voltage transmission lines, aircraft power supplies, and regulated switching power supplies for electronic equipment.

M.N. Yoder

ONR London

MICROWAVE DEVICE R&D AT MICROWAVE ASSOCIATES LTD

Microwave Associates Ltd (MAL), a wholly owned but virtually autonomous subsidiary of its American parent company with the same name, is in Dunstable, England, about 30 miles north of London. It was established in 1961 as a sales outlet for products of Microwave Associates USA and soon marketed approximately $500,000 worth of US products per year. After more than 20 years of operations it still markets about $500,000 worth of its US parent company's products per year. MAL additionally markets almost £500,000 worth of locally developed products; in fact, it is the largest independent supplier of microwave products in the UK. The company's largest customer is the Components, Valves (tubes), and Devices (CVD) group of the UK Ministry of Defence (MOD). MAL takes pride in its reputation within CVD as an organization that delivers products on schedule. In April 1981 the firm completed its most recent expansion, occupying an adjacent building wherein microwave communication equipment is produced. With these enlarged facilities the company secured a £1,000,000 contract for frequency synthesizer sources to be used by NATO SATCOM Phase III.

To accomplish its mission, MAL has found it necessary to become vertically integrated, with research and development activities supporting the production of devices and components not only for its own end-use-product subassemblies and subsystems but also for direct sale, tailored to the specific needs of customers. Managing director N. Bloom attributes the efficacy of the organization to the collocation of all of its integral components in a manner similar to the Japanese automobile industry. With this structure, scientific investigators and engineering developers rub shoulders with each other and with the production department. Additional benefits of the collocation include reduced interdivisional transportation costs and substantial reduction in the time required to resolve interdivisional problems. The centralized location also permits marketing director I.M.H. Williamson and his staff to become more intimately familiar with the company's products.

Currently MAL's semiconductor capabilities consist of a silicon epitaxial reactor (or "kit" as it is known in Britain), diffusion furnaces, and various optical lithography and metallization equipment. Under the direction of Peter Hogg the company has developed a product line of impact-avalanche-transit-time (IMPATT) and frequency-multiplier diodes for the generation and amplification of microwave signals. A line of various control diodes has also been developed. They include varactors for frequency tuning and PIN/NIP diodes for switching, limiting, and attenuating signals. Schottky barrier diodes for signal detection and superheterodyne mixing complete the list of semiconductor devices in the product line. An innovative approach has been used in MAL's step-recovery, frequency-multiplier diodes wherein a "flip chip" mounting is used. This significantly improves thermal conductivity and thus enables operation at higher power levels without sacrifice of upper frequency response. Snap times as low as 50 picoseconds are offered.

Using the above-described semiconductor devices, a group under the direction of Michael Nyss has developed a family of hybrid microwave integrated-circuit (MIC) switches. The MIC switch activity spans the spectrum of 0.5 to 13 GHz in coaxial modules and from 7 to 75 GHz in waveguide configuration. Using emitter-coupled-logic (ECL) drivers, the MIC switches exhibit typical transition times of less than 1 nanosecond and switching times of 6

nanoseconds. Drawing on assistance from the parent company in Burlington, Massachusetts, as required, MAL has developed various MICs for the radio frequency (RF) front ends or heads of several radar systems, radar test sets, and target simulators. To reduce signal losses in these equipments, a construction technique known as "suspended substrate" has been employed almost exclusively. Suspended substrate construction is characterized by the metal conductor being suspended midway between two metal conductors that also serve as the subassembly container. The electromagnetic signal is applied between the suspended metal and the container housing. Air is the dielectric medium and, of course, is very low loss.

Under the leadership of Peter Valckman, MAL recently entered into its most complex product line—that of digital frequency synthesizers. These new digital products have advantages over their analog predecessors. Among the attributes are (1) frequency agility, (2) frequency stability, (3) lower noise, and (4) faster set-on. The synthesizer product line now encompasses S, X, J, and Q bands.

Although semiconductor capability at MAL is currently constrained to two terminal silicon devices, this limitation will soon be lifted with the introduction in September of a gallium arsenide (GaAs) capability. This will enable the company to incorporate high-power, high-frequency transferred electron (Gunn) devices into its product line.

In summary, MAL has developed into a self-sufficient, vertically integrated facility. It has products ranging from semiconductor materials through microwave devices, components, and modules to complex subassemblies, many of which are custom designed for other corporations. The firm has earned a reputation for prompt delivery and has become the UK's largest independent microwave supplier.

M.N. Yoder
ONR London

MATERIAL SCIENCES

BLASTCOATING

Galvanized steel products have been available for many years, and the role of zinc as a sacrificial anode for protecting the underlying steel from corrosion is well known. Methods for applying zinc to the steel substrate, such as electrodeposition and hot dipping, are also well established. At the 8th International Conference on Organic Coatings Science and Technology held in Athens, Greece, on 12 to 16 July 1982, a new and novel method for applying zinc coatings was described by Dr. R.C. Groot of Sikkens Research Laboratories, The Netherlands.

Groot and his colleagues were searching for a better method for protecting steel structures from rusting between the time when their surfaces are prepared for painting and the time paint is actually applied. Customarily, steel is abrasive blast cleaned and then painted as soon as possible. For various reasons, however, days frequently go by before paint is finally applied to the cleaned surface. In the meantime the surface can rust, especially if the structure is in a humid or wet environment such as exists at coastal sites in Holland and England, and even though the rust layer is light and superficial, adhesion of paint applied to such surfaces can be markedly reduced. One way of avoiding this problem is to use a wet abrasive solution containing corrosion inhibitors for blast cleaning, but, while this gives some degree of protection, the inhibitors are easily washed off by rain and the protection is generally short lived. Blast coating, proposed by Groot et al as the alternative solution to the problem, is a variation of the wet-blast-inhibitor method. Instead of incorporating inhibitors in the abrasive solution, they recommended incorporating zinc particles, some of which they hoped would adhere to the steel surface during blasting and provide a sacrificial zinc coating for cathodic protection of the underlying steel surface. The method of application finally developed consisted of mixing zinc dust, small amounts of epoxy, and abrasive in a cement mill (along with unspecified additives, which, one surmises, might be wetting agents or antiflocculants) and applying the mixture to the steel surface using conventional blast-cleaning equipment.

Scanning electron microscopy of the particle mixture used for abrasive cleaning showed that the zinc was in the form of clusters of spheres attached to the abrasive particles by means of the epoxy resin. An examination of the steel surface after blast cleaning with the mixture revealed that the surface was covered with clusters of zinc particles, many of which were deformed upon impact, particles of abrasive, and epoxy films. As might be expected, the zinc coverage was not complete, but patchy; typical average zinc coverage was 5 to 9 mg/cm^2. Iron oxides were not found on the surfaces cleaned in this manner.

The blast-cleaned steel showed no visual signs of rusting for periods as long as several days depending on exposure conditions, and both surface analytical techniques and electrochemical measurements attested to the effectiveness of the process as a cathodic protection scheme.

To determine how well a zinc-coated, abrasive-cleaned steel surface accepted paint and how well paint adhered to surfaces so prepared, further tests were carried out. Steel panels were first blast cleaned with the zinc-coated abrasive, then exposed to salt

spray for times ranging from 0 to 2 hours, then rinsed with tap water, and while still wet were painted with a two-component, solvent-free epoxy applied by hot airless spraying. Paint thickness was about 400 μm. How well the surface accepted paint was judged qualitatively and ranking was from 10 (very good) to 1 (poor). Paint adhesion was tested by bonding a 1-centimeter-square plug adhesively to the painted surface and measuring the force necessary to pull plug and paint from the substrate. The results of the tests are listed with results for conventionally blast cleaned panels in Table I.

Table I - Adhesion and paint acceptance values for blast cleaned and Zn coated abrasive blast cleaned steel.

	Hours Exposed To Salt Spray	Paint Acceptance Value	Adhesion (daN)
Steel Conventionally Blast Cleaned	0	7	75
	1	2	0
	2	2	0
Steel Blast Cleaned With Zn Coated Abrasive	0	10	>117
	1	8	69
	2	6	65

It can be seen that, compared to conventional blast cleaning, the zinc-coated, abrasive-cleaning treatment affords a significant degree of protection to the steel substrate even under the rather harsh conditions of exposure to salt spray.

Encouraged by the results of this work, the group has developed a zinc-coated, abrasive-cleaning system for use under water. The process is similar to the original method except that the abrasive particles contain more zinc and blasting conditions are somewhat modified. The paint system employed for underwater painting, although of a different formulation than that used for application above water, is also a two-component, solvent-free epoxy applied by brush. Laboratory paint acceptance and adhesion tests gave results that are comparable to those shown in Table I for steels blast cleaned above water with zinc coated abrasives. Tests conducted in natural seawater have not been so encouraging, however. In these tests paint acceptance values and adhesion values were significantly lower than laboratory values, and reproducibility of values was not good. The cause is not known at this time, but biological contamination is suspected.

Based on results of tests to date, zinc-coated abrasive blasting looks promising. However, Groot pointed out that the process has drawbacks. For example, much more care has to be exercised in using this process than is necessary with conventional blast cleaning. In the first place, gas pressures and standoff distances during blasting have to be more closely controlled. Secondly, as the surface becomes covered with zinc, it is difficult to judge how well the surface has been cleaned. Finally, it is easy to build up zinc layers that are too thick and that can lead to poor paint adhesion. Some of the problems can be obviated by using automatic equipment; reproducibility, in particular, is improved when automatic equipment is used.

Regardless of its limitations, the zinc-coated, abrasive-cleaning method appears to offer an attractive possibility for providing short-term corrosion protection to structural steels.

P.A. Clarkin

ONR London

RAPID SOLIDIFICATION RESEARCH AT THE UNIVERSITY OF SHEFFIELD

Rapidly solidified alloys are as much a subject of interest in Europe as they are in the US, and many laboratories have research programs involving these materials. One such laboratory is at the Department of Metallurgy of the University of Sheffield, England, where a group of 15 to 20 with 4 staff is engaged in a variety of research projects on both rapidly solidified microcrystalline and amorphous materials. For the most part, the research has emphasized the structural aspects and mechanical behavior of these materials. Dr. Howard Jones, reader in metallurgy, whose primary interest is in rapidly solidified microcrystalline alloys, described his recent research and current programs on that subject at Sheffield.

Jones has been studying rapidly solidified aluminum alloys with extended solid solubility for several years. His original research on alloys of this type was an investigation of Al-Fe alloys carried out in the 1960s as a member of the research staff of Tube Investments Ltd. Since going to Sheffield in 1969 he has extended this work to other aluminum alloys. The first alloys he studied at Sheffield were of the Al-Zr system. This system was chosen because previous investigators had shown that some extended solubility could be obtained in Al-Zr alloys even at cooling rates of only about 10^3 K/s. Furthermore, they had not observed clustering in these alloys during quenching or afterwards. Clustering, which Jones had seen in his earlier studies of Al-Fe alloys, resulted in alloys with limited response to age hardening. Using levitation melting and a two-piston technique, Jones and his students were able to quench Al-Zr alloys with very high cooling rates, near 10^6 K/s, and to show that solubility could be extended to about 3 at %, about double the solubility limit obtained by previous workers. Moreover, the alloys did

not exhibit clustering and clearly responded to age hardening treatments.

Research was next undertaken by Jones and his group on Al-Cr alloys, which were expected to behave in much the same manner as Al-Zr alloys. Such was not the case, however. In the first place, quenched Al-Cr solid solutions were found to be very stable, much more so than Al-Zr solid solutions. Depending on Cr content and judged by lattice parameter changes, no appreciable precipitation was seen in Al-Cr solid solutions even after they were held at 480° to 580°C for 1 hour. In Al-Zr solid solutions, precipitation was experienced at temperatures as low as 350°C in 1 hour. In addition, despite the fact that no clustering was seen in Al-Cr alloys, they were not capable of being age hardened as Al-Zr alloys were. Instead of homogeneous precipitation within the grains, precipitation of the equilibrium phase Al_7Cr took place in Al-Cr alloys mainly at the grain boundaries with some precipitation later within the grains. The results were reported at the 4th International Conference on Rapidly Quenched Metals in Sendai, Japan, in 1981.

Recently, rapidly solidified ternary alloys of Al-Zr-Cr have been studied to determine if one could obtain an optimized alloy composition, i.e., an alloy that would exhibit the high-temperature stability of rapidly quenched Al-Cr solid solutions and the good age-hardening characteristics of Al-Zr alloys. The results of this research, which has almost been completed, are not particularly encouraging. The Cr and Zr additions in the alloy appear to function with no synergistic effects and the properties of the quenched ternary solid solution or of the aged alloy are simple additive functions of those of the binary alloys.

To complement the experimental programs being carried out, theoretical work is also in progress to determine the factors controlling extended solid solubility in rapidly quenched alloys. Recently reported results of this work concern quantifying the solidification front propagation velocities necessary to produce stable growth at high solidification rates without inducing cellular or dendritic growth accompanied by solute partitioning and eventual separation of a second phase. Using the Mullins-Sekerka criterion for stable growth fronts, Jones and his co-workers have calculated front velocities required for a number of alloys with extended solid solubilities. The velocities range from 60 mm/s for Al-6 at % Cr and 800 mm/s for Al-40 at % Mg, to as high as 4,000 mm/s for Al-16 at % Si alloys. But, according to Jones, such velocities cannot be achieved with the heat transfer conditions generally thought to exist in conventional processes for producing rapidly quenched alloys. They can be achieved, however, if it is hypothesized that during rapid quenching the melts are supercooled to sufficiently low temperatures, from 250 to 450°K in the case of Al alloys, so that when solidification begins, the heat of solidification can be accommodated completely within the volume of the melt. Under these circumstances the rate of solidification is independent of heat transfer to the surroundings. Experimental observations on rapidly solidified Al-Mg alloys tend to support the hypothesis.

Jones intends to continue research on Al base alloys and has recently commissioned a vacuum-controlled-atmosphere facility that will allow the production of kilogram quantities of rapidly quenched alloys of interest by spray deposition on a rotating chill block. He also is examining the melt extraction method for producing alloys and is investigating the influence of surface processes on the properties of particulates and fibers made by this method; a number of alloys are to be studied, including Al-Mg alloys and, eventually, stainless steels.

Another of Jones' interests concerns spray casting techniques (continuous spraying of molten drops on a chilled surface) for building up thick deposits of rapidly quenched alloys. He is trying to determine the material and process parameters that control and limit the maximum thickness of rapidly quenched layers that can be achieved with this method. To date, a heat and fluid flow model of traveling spray droplets has been developed to predict the velocity and temperature of the droplets at any time prior to deposition; this has been confirmed in experiments with spray-cast Al-Cr alloys. At the same time, experiments have shown that cooling rates of about 10^5 K/s can easily be achieved in spray-cast deposits as long as the deposit is thinner than 2 mm. Hardness measurements of deposits thicker than 2 mm indicated that high cooling rates were not being achieved in these samples. Whether the hardness changes truly reflect a lower cooling rate during deposition of thick deposits or are, instead, a consequence of heat treatment of the underlying deposits during deposition of subsequent overlayers or due to poorer thermal contact with the substrate in thick layers, is not known. Pulse spraying experiments are currently in progress to try to clarify the situation.

Besides Jones' research on Al base alloys, a number of other research programs on rapidly solidified materials are being conducted by his colleagues, Drs. H.A. Davies, D.H. Warrington, and R.A. Buckley. The programs include: (1) studies of the structure and properties of rapidly solidified copper alloys, such as Cu-Cr alloys; (2) a determination of the structure and properties of nickel-base superalloys, such as Nimonic 80A, IN100 and IN718, produced by a variety of rapid solidification techniques (e.g., atomization, roller quenching, and melt spinning); (3) an investigation of the influence of process variables on ribbon or strip dimensions and surface quality of alloys produced by chill block melt spinning and planar-flow casting (which is similar to melt drag processing); (4) research on the influence of combined additions of refractory

metals and chromium on the glass-forming ability, thermal stability, and properties of iron base and nickel base metallic glasses; (5) research on structural relaxation and embrittlement during annealing of glasses based on iron, nickel, and cobalt; (6) a study of the structure of binary metallic glasses in the Ni-B system using samples made with various isotopes of Ni for neutron scattering experiments; (7) a neutron and x-ray diffraction study of chemical short range order in Ti-Cu and Ni and Mn based alloys.

In terms of numbers of people involved and the variety of research programs on rapidly solidified alloys, the group at Sheffield is among the most active in England conducting research on this class of materials. The systematic studies of the influence of process variables on structure produced are particularly noteworthy.

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MATHEMATICS

EXPERIMENTS ON MEMBERSHIP IN FUZZY SETS

In 1965, L.A. Zadeh (Univ. of California, Berkeley) introduced the concept of fuzzy sets, primarily for application in problems of pattern classification and information processing (L.A. Zadeh, Fuzzy Sets, Information and Control [1965]). Zadeh defined a fuzzy set A in a universe X by a membership function $\mu_A: X \to [0,1]$, where for each $x \in X$, $\mu_A(x)$ represents the "degree of membership" of x in A. The nearer $\mu_A(x)$ is to 1, the higher the grade of membership of x in A. As a special case, when A is a "crisp" subset of X (that is, A is an ordinary, nonfuzzy set), the membership function can be taken to be the characteristic function of A with values in {0,1}. In an earlier ESN article, R.E. Machol discussed fuzzy sets and gave some examples of their application (ESN 35-3:124 [1981]).

Fuzzy sets have been used in mathematical models of situations involving the imprecision or vagueness of natural languages and human argumentation. It has been argued that human thought processes and communications through a language are inherently fuzzy rather than crisp. Thus when a manager states that it is desired to achieve large gains in production, the concept of "large", applied to gains in production level, is fuzzy. There may be a range of values that have varying degrees of largeness related to gains in production. In a decision modeling context, for example, it may be useful to define the set of large gains to be a fuzzy set, rather than attempt to define a threshold for largeness, with an associated crisp set of large gains.

As virtually all mathematical objects can be viewed as sets, there is a vast potential for studying the fuzzy analogs of these objects. For example, a function $f: A \to B$ can be viewed as a certain (crisp) subset of $A \times B$. Suppose one replaces the crisp set f with a corresponding fuzzy set μ_f. It is appropriate to ask, "What interesting properties and applications do such fuzzy functions have?" (One could study fuzzy continuity, fuzzy derivatives, and so on.) There have been a great many papers in recent mathematical literature concerning fuzzy functions, fuzzy topologies, fuzzy integrals and the like.

One of the most active members of the fuzzy-set community is Prof. Hans Zimmermann (Inst. of Technology of Aachen, FRG). Zimmermann has been active on the editorial board of the European Journal of Operational Research, and he was the main organizer of an international journal devoted to fuzzy sets and their applications, called Fuzzy Sets and Systems. Zimmermann's recent research on fuzzy sets has included applications to linear programming with several objective functions and to empirical investigation of logical connections used in human decision making. Recently the author visited Zimmermann; in what follows, some of his current research concerning membership functions is described.

In many optimization problems it is desired to maximize several objectives or criteria. The criteria are often represented as components in an objective vector. It is usually not possible to find a value of the variable vector (whose components represent the controls available to the decision maker) that simultaneously maximizes all components of the objective vector, so various approaches are used to reach a best compromise. This is the "vector maximum" problem: maximize Z(x), subject to the constraints $x \in X$, where $Z: R^n \to R^k$. Usually, attention is constrained to nondominated x's, that is, points in X for which there do not exist other points in X with better Z images. It is generally accepted that any optimal compromise solution must be nondominated.

Zimmermann has worked on the use of fuzzy sets in the solution of linear programming vector maximization problems. He considers the objective function and constraints to be fuzzy. As it is desired to satisfy the objective functions as well as the constraints, a decision in a fuzzy environment is defined to be a selection of activities that simultaneously satisfy objective functions and constraints. In fuzzy-set theory the intersection of sets corresponds to the logical "and". The decision in a fuzzy environment can therefore be viewed as the intersection of fuzzy constraints and fuzzy objective functions. One can represent the intersection of fuzzy sets in various ways; perhaps the simplest and most common method is through the minimum operator. Thus the

intersection of fuzzy sets A and B is a fuzzy set C with membership function

$$\mu_C(x) = \min\{\mu_A(x), \mu_B(x)\}.$$

Applied to linear programming, the fuzzy decision can be defined as the point having the highest degree of membership in the intersection of the objectives and constraints. A simple example of this approach is described in the article by Machol, cited above. In contrast to most nonfuzzy vector maximum solutions, in the fuzzy approach the nondominated points in X are distinguishable by their different degrees of satisfaction of the constraints and objectives.

There has been a great deal of discussion in the fuzzy set literature concerning the relationships between connectives (such as "and" and "or") as actually used by decision makers in linguistic settings and the corresponding-set theoretic operators. For example, it was mentioned above that "and" is usually interpreted as intersection and that, in terms of fuzzy sets, intersection often is taken via the minimum operator. However, there is empirical evidence that the minimum operator may not provide an adequate representation of "and" as it is actually used in communications among humans. A number of alternatives to the minimum operator have been suggested, following various approaches. Some of the approaches are axiomatic; under seemingly reasonable sets of axioms, the form of the operator has been derived by Hamacher (Third European Meeting on Cybernetics and Systems Research [1976]; and Baldwin and Pilsworth (Fuzzy Sets and Systems [1980]).

Zimmermann and one of his colleagues, P. Zysno, have undertaken a series of experiments designed to provide some information about the latent connectives used by humans in relation to decision making. Some of the results suggest that the use of the minimum operator to define the optimal decision in a fuzzy environment may not always be appropriate. According to Zimmermann, in observing actual managerial decisions one finds that there are hardly any decisions with no compensation between either different degrees of goal achievement or the degrees to which restrictions limit the scope of decisions (which would occur with the minimum operator). By "compensation," Zimmermann means that in rating objects with respect to a composite attribute, humans do not process the relevant information as if they are choosing the smaller of two grades of membership. Rather, they proceed as if they are using the smaller value for a general orientation but modify it in the direction of the higher value. On the other hand, the compensation rarely ever seems "complete" such as would occur with the maximum operator. This led Zimmermann and his co-workers to consider possible forms of additional new operators that imply a degree of compensation somewhere between the extremes of the minimum operator and the maximum operator. They performed some simple experiments to investigate a new operator they call

Table 1. Empirical and predicted grades of membership.

Item	μ_M	μ_C	$\mu_{M \cdot C}$	min	Product
bag	.000	.985	.007	.000	.000
baking tin	.908	.419	.517	.419	.380
ballpoint pen	.215	.149	.170	.149	.032
bathtub	.552	.804	.674	.552	.444
bookcover	.023	.454	.007	.023	.010
automobile	.501	.437	.493	.437	.219
cash register	.629	.400	.537	.400	.252
basket	.847	1.000	1.000	.847	.847
refrigerator	.424	.623	.460	.424	.264
swing	.318	.212	.142	.212	.067
lamp	.481	.310	.401	.310	.149
nail	1.000	.000	.000	.000	.000
parking meter	.663	.335	.437	.335	.222
pram	.283	.448	.239	.283	.127
press	.130	.152	.101	.130	.067
shovel	.325	.239	.301	.239	.078
spoon	.969	.256	.330	.256	.248
hammer	.480	.012	.023	.012	.006
water bottle	.546	.961	.714	.546	.525
wine barrel	.127	.980	.185	.127	.124

the "compensatory and." In one experiment, subjects were individually asked to grade the percentage of membership of various items in the categories metallic object (M), container (C), and metallic container (M∩C). Based on a pretest, some initial adjustments in the set of items to be used in the experiment were made in order to make the subjective levels of membership fairly evenly spaced from 0% to 100%, and to make the correlation between metallic object and container membership levels nearly zero. The median (over subjects) transformed grades of membership of the selected objects in the three sets M, C, and M∩C are shown in the table above, along with values of $\mu_{M\cap C}$ predicted by the min-operator and the product operator. Of the two, the min-operator gives the best explanation of the values of $\mu_{M\cap C}$ actually assigned by the subjects, although the fit is not that good. It was found that a much better fit could be obtained by using a modified operator of the form $\alpha \cdot \min\{\mu_c, \mu_m\}$.

In another experiment, the subjects, 60 students at the Institute of Technology of Aachen, were asked to grade 24 fire-wall tiles in terms of two attributes, solidarity and fit of dovetail. The subjects also rated the tiles in terms of their degrees of membership in the fuzzy set "ideal tile." With the data obtained, it was possible to measure how well various operators on the fuzzy sets "good solidarity" and "good fit" were able to track the values assigned to "ideal tile." (The tiles were presented to each subject in random order and half of the subjects made judgments of membership in ideal tile first while the other half judged levels of good solidarity and good fit first.) Four operators were examined: minimum, maximum, arithmetic mean, and geometric mean; the last two represented some degree of compensation in the levels of membership of each tile in the good-solidarity and good-fit sets. It was concluded that the geometric mean operator gave the best fit to the ideal-tile membership levels.

Zimmermann has investigated a family of operators based on an averaging of the intersection and union membership functions. With fuzzy sets A and B, the operator, θ, gives a fuzzy set with membership function

$$\mu_{A\theta B} = \mu_{A\cap B}^{1-\delta} \cdot \mu_{A\cup B}^{\delta}, \text{ where } 0 \leq \delta \leq 1$$

is a parameter of the family, called "grade of compensation". With intersection and union of fuzzy sets defined as product and sum, respectively, the symbolic definition of the operators becomes

$$\mu_\theta = (\Pi\mu_i)^{1-\delta} \cdot (1-\Pi(1-\mu_i))^{\delta},$$

where the μ_i's are between zero and one. With extreme values of δ, it is seen that intersection and union are members of this family of operators. For the data obtained in the tile-decision experiment, it was estimated that the grade of compensation was $\hat{\delta} = .562$, and with this value of δ, the resulting operator θ gives quite a good fit to the observed "ideal tile" data.

Zimmermann and his colleagues are currently carrying out further experiments with decision-maker subjects in an effort to clarify the forms decision models should have. The experiments are leading up to the extremely difficult problem of modeling human decisions from the point of view of applications of fuzzy sets.

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A RESEARCH AND DEVELOPMENT DECISION AID

The research manager faces a challenging task in making decisions concerning options available to him in the course of a research and development (R&D) project. Not only is the eventual outcome of a project unknown but the actual course that the work will take is usually uncertain at the times planning decisions are needed. Since the development of CPM (critical path method) and PERT (project evaluation and review technique) in the late 1950s, network analysis has become widely used as an R&D planning and decision aiding method. Perhaps the most commonly used type of network is the PERT diagram in which activities are represented by arrows and events by nodes. A node is not reached until all of its incoming activities are complete, and when a node has been reached, all outgoing activities must begin. More recently, GERT (graphical evaluation and review technique) was developed. This method, which involves a quantitative treatment of probabilistic networks, was developed as a review technique for the APOLLO project. A newer method of aiding the research manager has been developed by Mr. David G.S. Davies of the Fulmer Research Institute Ltd (UK). Development of this method, called "Research Planning Diagrams" (RPD), was initiated by Davies in the 1970s for use by the management at Fulmer.

According to Davies, there are two main reasons why research management may be reluctant to adopt the older networking techniques. First, the notation involved is inflexible and inconvenient. A serious defect in these systems is that decisions are not given due prominence. A second factor limiting the use of network analysis in research management is the cost of the planning process itself. Research plans often involve decisions in which the probabilities of choosing alternative paths are all nonnegligible. Extended sequences of such decisions result in a large number of

alternative overall paths that must be considered if the probability of success of the project as a whole is to be made as high as possible. Even in the absence of loops, with 5 simple binary decisions 32 paths must be considered, even though only one path will actually be followed. To manage the project properly, the implications of the alternative paths must be studied. Since there is a limit to the amount of effort that can be applied to planning, there is need for a simple, clear notation for research plans that will allow evaluation of alternative research decisions. The development of RPD methods was undertaken to overcome these difficulties. The Fulmer managers found RPD quite useful, and they decided to offer the method to the R&D management community at large.

RPD is a system of techniques for the planning and design of applied research projects. It covers two main sets of problems: problems of the decision maker who has the responsibility of authorizing or rejecting proposals and of making allocations of resources to the selected projects, and problems of the project manager who must schedule interdependent tasks while maintaining enough flexibility to handle unexpected contingencies. A first step in applying the RPD method is to represent the research project in terms of a diagram similar to a flow chart for a computer program.

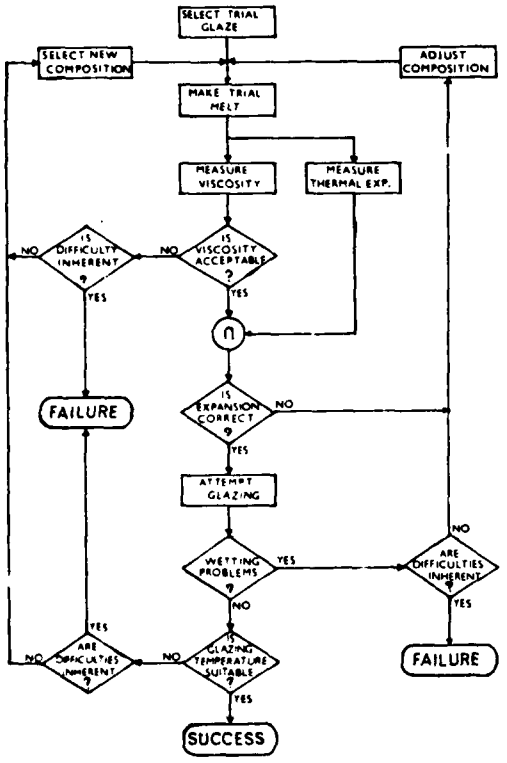

Fig. 1. RPD flow chart for a glaze selection project. The node with the symbol ∩ is an and-gate.

The diagram has value in providing a concise representation of the R&D project that is easily understood by the manager and easily communicated to others. An RPD for a simple example is shown in Figure 1. This plan is for part of a research program aimed at devising a glaze that will give satisfactory service as a high-temperature protective coating for certain metallic components. (It is assumed that previous phases of the work have already established criteria for the selection of trial glaze compounds.) The diagram in Figure 1 shows a project plan. Success would be achieved if the central vertical path with positive results on viscosity, thermal expansion, and glaze application were obtained.

The RPD lends itself to simple quantitative analysis by virtue of the sharp distinction between processes and decisions. In many applications, it is possible for the manager to form subjective estimates of times and costs of the processes and the probabilities of various decision outcomes. Once the plan has been drawn and the times, costs, and probabilities have been estimated, one can calculate the overall probabilities and costs for various paths through the network. From this, various analyses can be performed. An example of the type of output that can be obtained is shown in Figure 2 for the glaze selection example.

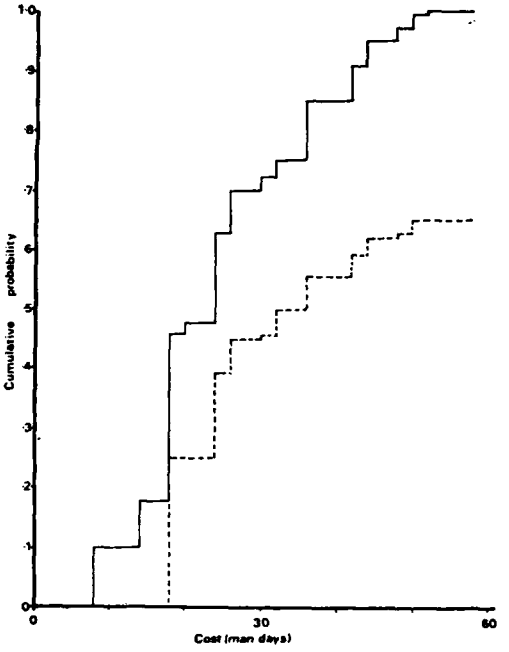

Fig. 2. Cumulative probability of reaching a conclusion (solid) and of reaching a successful conclusion (dotted), as functions of cost.

The cumulative probabilities of reaching a conclusion (solid line) and of achieving success (dotted line) are shown as functions of cost,

measured in man days of effort. Such information can be useful to the R&D manager. For example, this analysis could be used to suggest appropriate times for project review. It would perhaps be of little use to review the glaze selection project after 16 days, whereas review after 20 days might well give useful information. Among the potentially useful analyses are: plots of the conditional probability of ultimate success, given varying expenditures with no outcome reached; computation of probabilities of eventual successes or failures of various types; expected times or costs incurred to reach conclusion of the project; sensitivity analyses related to the subjectively determined inputs; cost-benefit analyses; tables of possible paths (perhaps sorted by probability of outcome); and various charts of times or expected times to reach selected conclusions. All of these analyses are based on the subjective estimates of times, costs, and probabilities input by the manager. They are thus subject to errors of unknown (and possibly large) magnitude. Nevertheless, the approach appears to provide useful information to the R&D manager for the planning and execution of a research project in an easily understood form.

To gain more insight into how the RPD procedure could be used, it is instructive to consider a specific example in somewhat greater detail. In what follows, we paraphrase a simple example given by Davies in a recent article, "R&D Tactics: Applications of RPD Decision Analysis," R&D Management, (1982). The example involves testing a newly developed ceramic material to determine whether it has sufficient strength and shock resistance. The material is judged to be a success only if it passes both tests. The manager has three options: (1) First measure the strength. If the material passes this test, then measure its shock resistance. (2) First measure the shock resistance. If the material passes this test, then measure its strength. (3) Carry out both measurements in parallel.

A diagram for options (1) and (2) is shown in Figure 3, and a diagram for option (3) is shown in Figure 4.

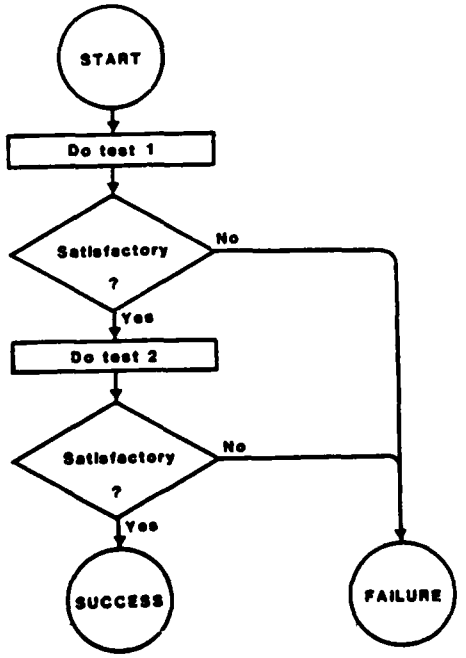

Fig. 3. RPD for series testing.

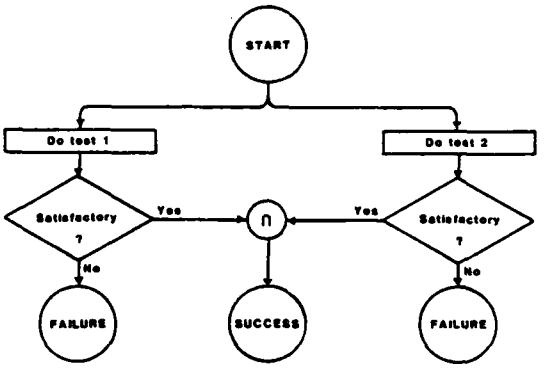

Fig. 4. RPD for parallel testing. ∩ denotes an and-gate.

Suppose under option (1) the cost of the strength test is C_1 and it is of duration d_1, and similarly for C_2 and d_2 for the shock resistance test. Let p_1 and p_2 denote the manager's subjective probabilities of success on the respective tests. There are three possible paths through the diagram of Figure 3: straight down to success (call this route [a]); branch to failure at test 1 (route [b]) and branch to failure at test 2 (route [c]). Suppose the benefit of reaching ultimate success is a function b of the elapsed test delay, whereas the benefit of reaching failure is 0. The serial option (1) can be viewed as a gamble with three possible results, summarized as follows:

Route	Probability	net benefit, v_1
[a]	p_1p_2	$b(d_1+d_2)-C_1C_2$
[b]	$p_1(1-p_2)$	$-C_1-C_2$
[c]	$(1-p_1)$	$-C_1$

The expected net benefit of option (1) is thus

$$E(V_1) = p_1p_2[b(d_1+d_2)-C_1C_2]+ p_1(1-p_2)(-C_1-C_2)-C_1(1-p_1) = p_1p_2\, b(d_1+d_2)-C_1-C_2p_1. \quad (1)$$

Reversing the order of the tests gives the expected net benefit of option (2):

$$E(V_2) = p_2p_1\, b(d_2+d_1)-C_2-C_1p_2. \quad (2)$$

In a similar way, option (3) can be viewed as a gamble with three possible results, and the expected net benefit is given by

$$E(V_3) = p_1p_2\, b(d_2)-C_1-C_2(p_1+(1-p_1)(d_1/d_2)). \qquad (3)$$

It is possible to compare the three options in terms of their expected net benefits. If the net benefits are reasonable measures or correlates of the manager's utilities of the various outcomes, he should seek the option maximizing the expected net benefit. Comparing equations (1) and (2), it may be seen that option (1) is preferred over option (2) (that is, one should perform the strength test first) provided that

$$\frac{C_1}{1-p_1} < \frac{C_2}{1-p_2} .$$

Note that this expression does not depend on the benefit function, b. (Davies points out that this result extends to the case of an arbitrary number of independent tests in series: the tests should be performed in order of increasing values of the corresponding ratios

$$\frac{\text{Cost of the test}}{\text{probability of failure of the test}} .)$$

Comparison of equation (1) and (2) with (3) shows that the parallel option should only be taken when $b(d_2)-b(d_1+d_2)$ is sufficiently large. That is, the parallel option is best only when there is a high premium on time. Otherwise, there is at least one series option that has better expected net benefit. The formal similarities between RPD and some of the information-based diagnostic models should be worthy of research attention.

The examples discussed here are quite simple, but the RPD technique is not restricted to such cases. Davies and others have applied the method to a large number of actual R&D management problems. The methodology is now being used by a number of government and private organizations in the UK, such as the Post Office Department and the Lucas Corporation. The Fulmer Research Institute sponsors seminars on the use of RPD, and it has developed software for carrying out the related analyses and displaying the results in easily understood forms.

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MEDICAL SCIENCES

NEURAL TUBE DEFECT RECURRENCE AND VITAMINS

Neural tube defects (NTDs) have grave consequences, they are relatively common in the newborn, and they also have a relatively high recurrence rate. If a woman has had one or more NTD babies, there is a probability of about 1 in 20 that she will have another at the next pregnancy. There seems to be no single causal factor, though several conditions are correlated with NTD occurrence. Social class, for instance, is negatively related to NTD likelihood. Several recent studies in the UK have explored the possibility of preventing some NTD recurrences by vitamin supplementation. The early results are encouraging enough for the Medical Research Council to plan a large clinical trial over the next several years.

K.M. Laurance (Welsh National School of Medicine, Cardiff) studied folic acid supplementation in a sample of 905 women, each of whom had previously had an NTD infant and was attempting to become pregnant again. Between 1969 and 1974, 111 of the cohort delivered babies; 51 were assigned to a placebo group and 60 to the experimental or supplementation group. Of the 60 experimentals, 16 were believed not to have taken their tablets, leaving 44 "true" experimentals. None of the "supplemented" women had an NTD recurrence; but among the 67 others (51 controlled and 16 noncompliers) there were 6 recurrences.

At the University of Leeds Department of Paediatrics and Child Health, R.W. Smithells, Sheila Sheppard, and their colleagues solicited prospective mothers in Leeds, London, Belfast, and Manchester. Requirements for inclusion in the sample were a previous NTD infant and a planned future pregnancy. (At Leeds, NTD included anencephaly, encephalocele, cranial meningocele, inicencephaly, myelocele, myelomeningocele, and meningocele; isolated hydrocephalus and spina bifida occulta were excluded.) A multivitamin preparation containing vitamins A and D, thiamin, riboflavin, pryidoxine, nicotinamide, ascorbic acid, folic acid, ferrous sulfate, and calcium phosphate was provided. Women who contemplated an immediate pregnancy were started on the vitamins immediately; others were asked to begin not less than 28 days before the planned conception and to continue at least through the second missed period. Those who followed this regime strictly were called "fully supplemented" (FS), and those who conceived shortly after starting the tablets or who missed one or more days were called "partially supplemented" (PS). More then half of the women in the sample were "unsupplemented" (US) (they were already pregnant when recruited but still in the first trimester). After the second month of pregnancy, all experimental supplementation was

stopped and vitamin intake thereafter was an individual matter. Several items of additional data were available for each mother, such as age, number of previous NTD births, and social class.

In the sample the number of previous NTD infants was a rather potent predictive variable: among the 270 unsupplemented women who had experienced only one NTD birth there was a total of 9 NTD infants this time, a recurrence rate of 3%; the group of 30 mothers with two previous NTDs had 4 recurrences (13%).

Supplementation effects seemed to exist when all the samples were accumulated. For all supplemented mothers (FS & PS), there was only 1 NTD among 256 infants and fetuses. In the unsupplemented sample of 305 infants, 13 NTD (4%) were recorded.

The Smithells-Sheppard team recognized that the trial, even though a large one, was not a true experiment with randomized assignment to conditions. They therefore examined alterative explanations of the data. Social class was one such possibility. There were, in fact, slightly fewer mothers at the higher social-class I and II levels in the US group. But the favorable difference in favor of supplementation still held when only the lower social groups III, IV, and V were included in the analysis.

One interesting difference between the FS and US recruitment procedures had to do with the outcome of immediately previous pregnancy. FS mothers were not yet pregnant but often planned to become pregnant again shortly after the birth of an NTD infant. US mothers were typically already pregnant when they were included in the study. Thus, the likelihood of an immediately preceding NTD pregnancy was higher (79%) in the FSs than in the USs (60%), but spontaneous abortions were less frequent (9% likelihood) in the FS set than in the US group (17%). Conceivably, as spontaneous abortion is known to be more frequent in NTD mothers, this could have caused the FS-US difference, although the Leeds researchers considered this explanation unlikely.

Abortion rates were similar in FS, PS, and US mothers; of 32 aborted fetuses, only 1 was found to have NTD, so that could not have been the explanation. A "general intervention" factor cannot be ruled out, however; when prospective mothers receive counseling at a major medical establishment, as the FS and PS women did, it is quite possible that they will receive several kinds of advice, information, and support. For example, positive suggestions on items like diet, smoking, and alcohol could have been the effective agents.

The simplest explanation, and the one favored by the Leeds researchers, is that vitamin supplementation probably prevented some NTDs. When taken together with the folic acid results from Wales mentioned earlier and the relatively low cost of vitamin preparation and administration, there seems to be some reason for optimism. The UK Medical Research Council is planning a large clinical trial that should furnish more precise answers within the next few years.

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OCEAN SCIENCES

RESEARCH VESSEL MANAGEMENT IN EUROPE

This report introduces many of the larger oceanographic research vessels in Europe. It also explains who uses the vessels and how they are managed. The principal sources of data were visits to many of the laboratories, letters from individuals at various laboratories, and a book, Jane's Ocean Technology. Dr. Feodor Ostapoff, of the US National Oceanic and Atmospheric Administration laboratory in Miami, Florida, furnished some information on Russian research vessels. The report is organized by countries, presented in a geographical relationship from west to east.

PORTUGAL

Most of the oceangraphic research in Portugal is centered in the Hydrographic Institute of the Portuguese Navy. The principal efforts of the oceanography programs in the navy are in practical and applied research. About half of the research at the institute has been requested and is usually paid for by other governmental departments and various industries. Much of the research is related to marine pollution and potential pollution from coastal power plants that are in the planning stage. The navy even runs the marine biology station in Lisbon, where the present emphasis is on aquaculture.

The Portuguese Navy operates and schedules the 191-ft Almeida Carvalho (ex-USNS on loan from the US Navy since 1972) and two 63-ft launches that are dedicated to oceanographic research. Occasionally, the 310-ft Alfonso De Albuquerque is used for oceanographic work.

From time to time a small cadre of physical oceanographers from the University of Lisbon takes part in navy oceanographic cruises.

SPAIN

The Spanish Institute of Oceanography owns, operates, and schedules the 165-ft oceanographic fisheries research vessel Cornide de Saavera. The main laboratory and headquarters of the institute are in Madrid. There are seven small branch laboratories around the coast of Spain and on the Spanish islands of Mallorca and Tenerife. The vessel is primarily used in the western Mediterranean Sea and the Atlantic coastal waters of Spain. Smaller vessels are frequently chartered for research

work close to the branch laboratories. The Cornide de Saavera is also available for use by other government agencies.

The National Center of Fisheries Investigation (CNIP) consists of four independent laboratories at Barcelona, Vigo, Cadiz, and Torre de la Sal. The Barcelona laboratory is the largest, and in addition to fisheries research carries out a broad program of oceanographic research and aquaculture. The Barcelona laboratory operates the 123-ft stern-ramp trawler-research vessel Garcia del Cid. The vessel is used by all four CNIP laboratories, the Institute of Oceanography, the universities, and other governmental agencies. The various users share in the cost of operating the vessel. The schedule for Garcia del Cid is established by a steering committee of two members (including the directors) from each of the four fisheries laboratories.

The Navy Hydrographic Institute, headquartered in Cadiz, operates six survey vessels.

IRELAND

Ireland's lone oceanographic vessel is the 76-ft Lough Beltra, based in Dublin. It is used for marine studies by staff members and students from Trinity College, University College, Dublin, and the Department of Oceanography of University College, Galway. The latter two schools are constituents of the University of Ireland.

BRITAIN

The Natural Environment Research Council (NERC) supplies most of the funds for British marine research in government laboratories and universities, with the exception of military, engineering, and fisheries research.

NERC operates a research vessel and oceanographic equipment pool with a home base at Barry, Wales. The largest ship in the fleet, the 254-ft Discovery, is primarily used by NERC Institute of Oceanographic Sciences, Wormley, about 30 miles south of London. The other vessels are the 201-ft Shackleton (often used for high-latitude research), the 181-ft Challenger, the 135-ft John Murray, and the 103-ft Edward Forbes. Schedules for each ship are made up to 2 years in advance. Most of the users either work in a NERC laboratory or are supported by NERC research grants, but individuals or groups without NERC funding may take part in NERC-sponsored cruises on a cooperative basis. Each NERC laboratory draws up its tentative ship schedule, which is then considered by a subpanel called the Seatime Assessment Committee. The committee draws up the final schedules.

NERC has a number of committees that decide on the awarding of grants to individual researchers in universities. The three marine science grant committees are marine biology, physical and chemical oceanography, and marine geophysics. These panels also receive ship-time requests from individual research workers and make recommendations to the NERC subpanel on ship scheduling.

The base at Barry also has a pool of oceanographic research equipment that is rented for fixed fees by individuals or laboratories using NERC ships. A feature of the operation of the pool is a small surcharge for insurance on each rental charge. The pool even furnishes trained technicians to operate complicated research equipment at sea. The arrangements for pooling research equipment and technicians make it possible for individuals in universities to carry out research projects at sea without a critical mass of assistants and equipment. To a large degree, this accounts for the fact that a high percentage of universities and colleges in Britain have some staff members carrying out oceanographic research.

In addition to NERC research vessels, there are several other research vessels in Britain. The Antarctic Survey supply ships are the 221-ft John Briscoe and the 328-ft Bransfield. The ships have berthing capacity for 28 and 60 scientists, respectively, and are frequently used for research in the Antarctic. The department of Agriculture and Fisheries in Scotland has two trawler oceanographic research vessels, the 262-ft Clupea and the 226-ft Scotia. They are used extensively for physical and chemical oceanography research around Scotland.

The British Ministry of Agriculture, Fisheries, and Food has three research vessels based at Lowestoft, the 239-ft Cirolana, the 155-ft Clione, and the 137-ft Corella. The vessels are used not only for extensive research in physical and chemical oceanography in support of fisheries and pollution research around the British Isles, but also for major cruises to the eastern basin of the North Atlantic. Here, researchers from the Lowestoft laboratory and other laboratories are studying the potential for the disposal of nuclear wastes on the bottom of the deep ocean. The Marine Biological Association, with its laboratory at Plymouth, owns, operates, and schedules the 129-ft Sarsia.

Universities that own their own research vessels are University College of North Wales (UCNW), which operates the 94-ft Prince Madog, and the University College of Swansea, which has the 100-ft Ocean Crest. The Dunstaffnage Marine Research Laboratory in Oban owns and operates the 70-ft Calanus.

A perennial problem is the mounting cost of operating expenses. The trend is toward obtaining funds from large governmental agencies, and often this has resulted in the loss of control of the vessels. It is a monument to the independence of the Welsh people that the only two universities in Britain that wholly control and operate their own sizable vessels are in Wales. The UCNW treats the Prince Madog as a campus building, thus being able to use operating funds for buildings and grounds to help operate the ship.

FRANCE

In France, most of the oceanographic research in university and governmental laboratories is funded by government agencies. However, CNEXO (Centre National pour L'Exploitation des Oceans) is in charge of all governmentally supported oceanographic research ships even if the research is not supported by CNEXO. Ownership or operation of research vessels by individual laboratories or agencies other than CNEXO is limited to ships with overall lengths of 79 ft or less.

CNEXO headquarters are in Paris, while the main laboratory and ship operation base are near Brest, on the northwest coast of France. CNEXO operates seven ships over 123 ft long. The Jean Charcot (246 ft), Le Noroit (167 ft), and Le Suroit (186 ft) are based in Brest. The ships can be stationed away from their home bases for periods of up to 18 months when scientific programs require work in distant waters. The 184-ft Nadir is based in Toulon for work in the Mediterranean Sea. The 124-ft Coriolis is based in Noumea, New Caledonia. The 154-ft Capricorn is based in Abijan, Ivory Coast (formerly part of French West Africa), and the 161-ft Cyros in St. Pierre, a French island off the coast of Newfoundland. The last three vessels are used for both oceanographic and fisheries research. CNEXO is designing a new ship to be built in 1983 - 1984.

Gaetan Stanislas, head of ship scheduling for CNEXO, states that only 60 to 70% of the needed ship time is available with the present CNEXO fleet. He believes that the need for more ship time will grow in the future, primarily for geological research. CNEXO itself is heavily committed to research related to obtaining metals from the ocean floor.

Priorities for the use of CNEXO ships are decided at two levels. First, each department of the government that uses research vessels makes up its own priority list. Next, representatives from the different departments meet to divide the available ship time among the various programs. The scheduling process is a lengthy one; for example, CNEXO received formal requests for 1982 ship time in December of 1980 and made up the final schedule for 1982 in July of 1981.

In addition to the CNEXO fleet, nine naval hydrographic ships have room to carry scientists and are equipped to do some oceanographic research. A governmental agency called Messageries Maritimes operates the 370-ft Marion Dufresne in high latitudes in the southern Indian Ocean as a joint oceanographic research vessel that doubles as a supply ship for subantarctic bases on French islands in that area.

Some marine laboratories in France operate small vessels under 79 ft in length. Examples are the two 73-ft vessels operated by the laboratory of Physical and Chemical Oceanography at Villefranche-sur-Mer. They are the Korotneff and the Catherine-Laurence. The laboratory is a part of the Pierre and Marie Curie campus of the University of Paris. The vessels are owned by the Centre National pour la Recherche Scientifique (CNRS)—the French equivalent of the US National Science Foundation. They are jointly operated by CNRS and the university (with funds from the Ministry of Education). Scheduling of the two vessels is flexible and is locally arranged and controlled. Persons outside the Villefranche laboratory also make use of the vessels for work in the Mediterranean.

BELGIUM

The University of Liege operates the 67-ft catamaran Recteur Dubuisson. Powered by two diesel engines, the ship has a cruising speed of 12 knots.

THE NETHERLANDS

Oceanographic research vessel operations are coordinated by the Netherlands Council for Ocean Research, a division of the Royal Academy of Sciences. The two large oceanographic research vessels in the Netherlands are the 297-ft Navy ship Tydeman and the 6,000-ton freighter Tyro. The Tyro is chartered by the council from a privately owned company, and its operations are managed by the Netherlands Institute for Sea Research (NIOZ) on Texel Island.

The civilian scientific community is allotted an average of 10 weeks of sea time aboard the Tydeman each year. Priorities for the use of both the Tydeman and the Tyro are set by a small management advisory panel that is a subgroup of the council. The council also makes up the operating schedule for the Tyro, while the Navy schedules the Tydeman. The principal users of the two vessels are NIOZ and the Oceanography Division of the Royal Netherlands Meteorological Institute (KNMI) in DeBilt, which also manages the weather ship Cumulus. A routine program of oceanographic observation is carried out aboard the Cumulus for KNMI, and the vessel also has been used for research cruises.

NIOZ also operates and schedules its own research vessel, the 105-ft Aurelia. Its time is fully occupied by researchers from NIOZ. NIOZ uses about 15% of the Tydeman's time and 30% of the Tyro's time. Schedules for the Aurelia, which is primarily used for short cruises and cruises in the North Sea, are made up about 6 months or less in advance, while preliminary scheduling of the two larger ships is done 2 years in advance.

NORWAY

The Norwegian Defense Research Establishment owns, operates, and schedules the 128-ft research vessel H. U. Sverdrup. The establishment uses about half of the available ship time, with the remainder taken up by various other research institutions in Norway.

The University of Bergen has recently acquired a modern research vessel, the 119-ft Hakon Mosby. The University of Tromso and

the Nordland Regional Laboratory at Bodoe operate small research vessels just under 66 ft in length. Scheduling is by each institution.

The Institute of Marine Research of the Directorate of Fisheries owns, operates, and schedules the 176-ft Johan Hjort, the 172-ft G. O. Sars, and the 152-ft Michael Sars. The vessels are equipped to do hydrographic work, dredging, and bottom sampling.

C.C. Reiber and Co., of Bergen, owns and operates three especially designed combination icebreaker and high-latitude research vessels that are almost identical. The 165-ft ships are the Polarsirkel, the Arctic Explorer, and the Polarbjorn. Each carries a helicopter, which makes them especially useful for studying ice fields and icebergs. They are chartered by universities, governmental agencies, and industry for resupply work and research in Arctic and Antarctic regions. Efficient management and careful design keep the charter rates below the normal operating costs of vessels of their type.

SWEDEN

Sweden's Oceanographic Institute is part of the University of Göteborg. It owns, operates, and manages the Svanic, a 102-ft steel trawler. The vessel's schedule is made up for 6 months at a time with priority given to the university. A fourth of the ship's time at sea is taken up by external users, who are charged only $180 a day because the university subsidizes the vessel's operational costs.

The government's Hydrographic Department operates eight research vessels with lengths of 89 to 215 ft.

FINLAND

The Hydrographic Department of Finland's National Board of Navigation and Shipping operates three survey vessels, the Tauvo (102 ft), the Sarkka (92 ft), and the Airisto (101 ft). The Airisto, built in 1973, is used mainly for seabed mapping, for which it is equipped with underwater wings that extend 66 ft from each side of the hull. Echo sounders in the wings enable the 13-member crew to chart the seabed acoustically.

DENMARK

The Danish Institute of Physical Oceanography is part of the University of Copenhagen. The institute has no research vessels of its own. Researchers from the institute participate in joint projects with Danish fisheries researchers aboard their vessels based in Denmark, the Farve Islands, and Greenland. Joint projects also are carried out with researchers from the Danish Ministry of Environmental Protection aboard the ministry's vessels. These include the 121-ft Martin Knudsen, which the ministry charters from a West German shipbuilding company.

WEST GERMANY

The Institut für Meerskunde, Kiel, owns, operates, and schedules the 201-ft oceanographic research vessel Poseidon. The ship is used almost entirely by researchers from the institute. Its operation is much more flexible than most research vessels in that the operating schedule is only fixed for 2 months in advance. The cost of operating the ship is paid by the state of Schleswig Holstein. The institute also owns, operates, and schedules the 102-ft Alkor, also used primarily by institute personnel.

Although the Institut für Meerskunde is adjacent to the University of Kiel, it is not a part of that school. However, marine research is carried out by members of the biology, geology, and physics departments of the university. The German Research Association (DFG), roughly the equivalent of the US National Science Foundation, funds large multidisciplinary research projects lasting about a decade, the same way the NSF funded projects under the recent International Decade of Ocean Exploration program. Researchers from the university and the institute in Kiel are working together on one of these large projects to study interaction between bottom sediments and the overlying water. For this research, they use the 97-ft research vessel Littorina. The ship's operation is funded by DFG and the ship is manned and scheduled by a local committee.

The queen of the German research fleet is the 271-ft Meteor, jointly maintained by the German Hydrographic Institute (DHI) in Kiel and DFG. DHI operates and schedules the vessel, which is used extensively for long, deep-ocean cruises by personnel from a number of German institutes and universities.

The civilian research organization of the German navy owns, operates, and schedules the research vessel Planet primarily for underwater acoustics and survey work. About a quarter of Planet's time is allotted for civilian-scientist use, usually for long multiship projects.

The 264-ft Valdivia is funded by DFG. It is based in Hamburg and used on a decade-long multiple-disciplinary study centered around the Max-Planck Institute for Meteorology, which is located, along with the Institutes of Geophysics and Meteorology, on the campus of the University of Hamburg. There also are two large fisheries-biology research vessels stationed in Hamburg that carry out some fisheries-oriented oceanography.

A new Polar Research Institute has been established in Bremerhaven. The icebreaker Polarstern, 389 ft long, can accommodate 106 people. A new polar research vessel is under construction (see ESN 36-4:79 [1982]).

ITALY

The Italian National Council for Research owns and operates three research vessels, the 205-ft Bannock, the 181-ft L.F. Marsili, and the 101-ft fisheries-marine biology research vessel

Salvatore Lo Bianco. The Bannock is a refitted US Navy ocean fleet tug.

Two of the principal users of the Bannock and the L.F. Marsili are the Physical Oceanography Laboratory of the Observatory for Experimental Geophysics (it also often uses chartered vessels when carrying out ocean-engineering studies for industry) in Trieste, and the Oceanography Research Group of the Institute of Hydrobiology and Fish Culture of the University of Genoa.

The Italian Council for Research also owns the 80-ft Umberto D'Ancona, which is used primarily by the Institute of Biology of the Sea in Venice.

GREECE

Until recently, the Greek navy was the only organization in Greece that owned and operated research vessels. Scientists from other organizations are invited on all navy oceanographic cruises and use navy-owned equipment. Users include persons from the Institute of Oceanography and Fisheries, the Ministry of Coordination, the University of Athens, and the Ministry of Public Health. A large fraction of the research carried out on naval ships is concerned with pollution and potential pollution. The Navy operates and schedules a specially built oceanographic vessel, the Naftilos, and several launches.

The large governmental Institute of Oceanography and Fisheries is closely affiliated with marine researchers at the University of Athens.

YUGOSLAVIA

The Hydrographic Institute of the Yugoslavian Navy has four survey vessels that are used for some oceanographic work. The Institute of Oceanography and Fisheries at Split has two small research vessels. Unfortunately, Jane's Ocean Technology provides few details on this nation's ships.

POLAND

The Polish research vessel, Hydromet, 108 ft long, is operated by the State Institute of Hydrology and Meteorology. The institute also operates a 66-ft scientific sailing yacht, the Gedania. Poland has five fisheries research ships, ranging from 76 to 297 ft, vessels used mainly for ichthyology and fisheries technology studies.

THE SOVIET UNION

The 1979-80 volume of Jane's Ocean Technology lists more than 100 marine research vessels in the Soviet Union. Many of the ships are large compared to research ships in other countries. This is particularly true of vessels that were added in the two decades following World War II. Ten or more are over 6,000 tons displacement, with one at 11,000 tons and another at 21,250 tons. In recent years, the Soviet Union has added many smaller vessels of the size of the Woods Hole Oceanographic Institution's larger vessels. Some of these are class vessels with as many as 16 hulls of the same type.

Three of the larger operators of research vessels are the Soviet Academy of Sciences, the Hydrometeorological Service Administration, and the Ministry of Fisheries. Some of the larger vessels, 6,700 tons and over, carry crews of up to 100, have scientific complements of about 50, and take long cruises ranging from three to six months. Oceanography is done in support of fisheries, the country's merchant fleet, and naval operations.

The 511-ft Kosmonaut Vladimir Komarov, operated by the Academy of Sciences, is the world's largest research vessel. It is believed the vessel has been used principally in connection with satellite work and interplanetary probes. Originally launched as a merchant ship in 1966, it was converted to its present role in 1967 and renamed in honor of a Soviet astronaut.

Another vessel operated by the Soviet Academy of Sciences is the expedition ship Akademik Kurtchatov, an oceanological and meteorological research vessel with an overall length of 408 ft. One of a class of seven, the vessel has a helicopter landing platform, a cruising speed of 18.2 knots, and three main decks. Outfitted with 26 laboratories, it is designed to carry 81 scientists plus a crew of 85. In the 1970s, the ship was in the Caribbean Sea to participate in a study of air-sea interactions sponsored by the United Nations Educational, Scientific, and Cultural Organization (UNESCO).

According to Ocean Science News (Jan. 25, 1982), the Soviets launched a new research vessel in December, 1981. Named the Vityaz, the ship is part of the nation's Academy of Sciences fleet. The original vessel of the same name has been retired. In the hold of the Vityaz is a hanger for manned underwater vehicles that can be raised on its platform to main deck level. Built into the hull is a hyperbaric complex for diver compression. Prof. V.S. Yastrebov, deputy director of the USSR Oceanography Institute, was quoted as having said that one of the ship's first missions will be to investigate the Ampere seamount, near Gibraltar, with the help of the submersible Argus. Some Soviet scientists suspect that some unusual structures on the seamount may be the remains of an ancient city, while others believe them to be geological, Yastrebov stated. No information was given regarding the ship's length or displacement.

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PHYSICS

EXCIMER LASER DEVELOPMENT AND APPLICATIONS AT IMPERIAL COLLEGE AND RUTHERFORD APPLETON LABORATORY

An extensive program on the development and utilization of rare gas halide excimer lasers is under way in the UK. Two prominent groups spearheading the effort are the laser laboratories at Imperial College and the Rutherford Appleton Laboratory (RAL). The author had the opportunity to visit both laboratories recently and was shown an impressive array of experiments that demonstrated the diversity as well as the high standard of excimer laser activities in the UK.

Excimer laser research at Imperial College dates back to the mid-1970s, when scientists there pioneered the development of the rare gas excimer laser. More recently the emphasis of the group has shifted to the rare gas halide excimers. At present approximately 12 scientists and graduate students, under the direction of M.H.R. Hutchinson, are engaged in the development and application of UV-VUV excimer lasers. At their disposal are an e-beam, sustained-discharge device capable of producing 300-ns pulses and a number of UV preionized discharge lasers with shorter output pulses. Plans are being made to build a sizable discharge pumped device with X-ray preionization.

Rare gas halide lasers are characterized by storage times of several nanoseconds. Since optimal efficiency for these lasers is realized for much longer pump pulse durations, techniques for pulse compression are of interest in applications where nanosecond or subnanosecond optical pulses are required. Hutchinson and his colleagues have been investigating the physics of stimulated Brillouin scattering in tapered waveguides for this purpose. The scattering medium is contained in a waveguide with length equal to half the length of the optical pulse to be compressed. A backward traveling Stokes signal is generated spontaneously at the far end of the waveguide. As the intensity of the Stokes pulse builds up, its leading edge begins to deplete the pump, leaving a weaker pump to amplify the trailing portion of the pulse. Pulse steepening and thus compression results. The Imperial College group has calculated that, using methane as the scattering medium, a 30-ns KrF laser pulse can be compressed to 1 ns with greater than 80% efficiency. Experiments designed to verify some of the predictions are now under way.

The bulk of future experiments in Hutchinson's group will be carried out using a narrow-band excimer-dye laser system now under construction. The output from one excimer laser will be used to pump two separate single-mode dye lasers, one of them tuned to twice the wavelength of a second excimer laser. The output from this dye laser, after frequency doubling, will serve as either an injection locking source or the input into the second excimer amplifier. The group will then have at its disposal simultaneously an intense single-frequency excimer laser source and a synchronized tunable single-frequency dye laser source. When the system becomes operational, the group plans to initiate experiments in the areas of resonant four-wave mixing, switched collisions, and multiphoton interactions with giant dipoles.

Excimer laser research at RAL is directed by F. O'Neill, who heads the laser development group in the Laser Division. The primary thrust of the group's activities is the exploitation of excimer lasers for the production of plasmas. An e-beam pumped excimer device (SPRITE) 25 cm in diameter and 100 cm in length was recently completed. The unique feature of the device is that electron beams enter the laser chamber from four sides, creating a highly uniform volume of excitation for the active medium. Thus far, output energy of 160 J has been extracted on KrF in a 40-ns pulse from this device at an overall efficiency of 0.75%. It is projected that improvements in the system will enable an energy of 300 J in a 60-ns pulse with an overall efficiency of 1.5% to be achieved. As it is, SPRITE is the most powerful excimer laser ever reported in the open literature.

RAL has plans to compress the energy contained in the 60-ns pulse into 1 ns for laser plasma experiments. To accomplish this, the energy will be extracted from SPRITE with five input beams of 12-ns duration in an angularly multiplexed manner. That is, the five input beams will be sent into the amplifier sequentially and at slightly different angles. The five amplified beams will then be used to pump a Raman amplifier, again at different angles, but this time in synchronism. Finally, through yet another angular multiplexing arrangement, energy in the five pump beams will be extracted with twelve 1-ns input Stokes beams. The result will be 12 Raman shifted beams of 1-ns duration whose combined energy should be approximately equal to the available energy from SPRITE.

The people in the laser development group are also engaged in a number of experiments that capitalize on the excimer laser expertise they have developed. For example, they recently completed experiments that demonstrated for the first time high-quality phase conjugation of KrF laser radiation through stimulated Brillouin scattering. Not only did they obtain good conjugate fidelity, but they also observed reflectivity as high as 80%. The author was also shown a new excimer laser facility in its embryonic stage. This facility will be made available to collaborators from various universities who will use the laser sources to conduct experiments in laser photochemistry, plasma

diagnostics, laser annealing, and photolithography.

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HIGH-POWER GLASS-LASER RESEARCH

The achievement of inertial-confinement fusion (ICF) is actively being pursued in research programs within the United States, Japan, western Europe, and eastern Europe. The repetitive thermonuclear explosion of targets containing a mixture of deuterium and tritium (DT) in a full-scale reactor would provide electrical power with the hydrogen isotopes extracted from sea water. In less complex system configurations, ICF has application to weapons development and the laboratory simulation of nuclear bursts for weapons-effects studies.

The major part of ICF research in the world is associated with the use of high-power lasers to drive the thermonuclear microexplosion. Optimistically, DT ignition might be achieved with uniform irradiation of a spherical target a few mm in diameter by a number of focused laser beams producing of order 10^{16} W/cm^2 for several ns. The simplest target designs with substantial thermonuclear yield consist of an outer shell of low-atomic-number ablator material (i.e., plastic) surrounding a heavier material "pusher" shell. Either the interior volume is filled with DT gas or frozen DT is deposited on the inner wall of the pusher. The laser energy is absorbed in the ablator, converting it to a plasma at a few hundred eV which blows away from the pusher and fuel. The recoil momentum of the blow-off plasma and its pressure compress and heat the fuel to about 1,000 times solid density and several keV temperature. Under these conditions, the DT fuses and releases most of the thermonuclear energy in the form of 14 MeV neutrons. In an ICF reactor producing power, the neutrons are stopped in a working fluid (perhaps liquid lithium) contained within a wall surrounding the target. The neutron-heated fluid drives some thermal cycle that produces electricity. A portion of the electricity provides the energy for the next laser pulse. Commercially useful levels of electrical power require 10 to 100 microexplosions per second. A much lower duty cycle suffices in a nuclear-weapons-effects simulator where no electricity is produced. In that application, the X-radiation emitted by the explosion is used to irradiate materials, weapons subsystems, satellites, etc., to determine their response to radiation and to establish hardening requirements.

Recent visits to Rutherford Appleton Laboratory (RAL) in Chilton, Oxfordshire, UK, and the Commissariat a l'Energie Atomique, Centre d'Etude de Limeil (CEA Limeil) in Villeneuve-Saint-Georges, France, have indicated comprehensive research programs addressing the major obstacles to the achievement of laser-driven ICF. The chief problem areas are:

(1) inadequate laser energy for large thermonuclear yields (perhaps several MJ will be required),
(2) inefficient coupling of laser energy into the target (high reflectance is associated with flux levels required for ignition),
(3) superthermal-electron production (hot electrons produced in the ablator penetrate into the fuel, preheating it so that sufficient density compression cannot subsequently be achieved),
(4) implosion asymmetry and instability (preventing high-quality implosions to sufficient density).

By necessity, many approaches to research in these problem areas and techniques for their resolution are common to both laboratories. Both employ multibeam Nd-glass lasers that produce light in the near infrared at 1.06-μm wavelength. However, a critical issue is the choice of optimal wavelength for maximum coupling to the target with acceptable levels of superthermal electron production in geometries that provide smoothing of nonuniformities and prevent fuel preheat. Therefore, both laboratories utilize KDP harmonic-generating crystals that can efficiently frequency-double (2ω) the laser radiation to .53 μm in the green. Combination of the 2ω component with the remaining infrared in a second KDP crystal results in a frequency-tripled (3ω) component at about .35 μm in the near ultraviolet. Both laboratories have studied the interaction of these radiations with spherical targets using multibeam irradiation. An additional beam line is used to study laser-matter interactions in planar-foil targets at the three wavelengths. Both laboratories can operate the multibeam or probe-beam laser in a short-pulse (≈ 100 ps) mode or long-pulse (≈ 1 ns) mode. Both employ a single line focused on a high-atomic-number target to produce soft X-radiation to backlight the implosion of spherical targets and ablative blow-off of planar targets. X-ray streak and framing photographs of the implosion employing this shadowgraph technique are used to observe the growth of asymmetries and instabilities and to benchmark sophisticated hydrodynamic codes that model the target motion. Spherical targets are loaded with DT so that neutron-yield measurements can be used to determine the implosion quality. In what follows, a few of the experimental techniques and results that are unique to each laboratory and have application to areas outside laser-driven inertial-confinement fusion are emphasized.

The Rutherford Appleton Laboratory is organized into a number of research boards, one of which, the Science Board, contains the

neutron-beam and laser research. The VULCAN Nd-laser facility is directed by the Glass Laser Scientific Programme and Scheduling Committee comprised of scientists from RAL and the University College of North Wales, Imperial College, Hull University, and Essex University. University members chair the various research groups while RAL members act as group secretaries. (The name VULCAN represents the Roman god of fire and patron of workers with fire, including plasma physicists.) The laser consists of six 100 J beams extracted from final disc amplifiers in the 1-ns-duration mode. Lower energy but somewhat higher power (limited by damage to optical coatings) is achieved in the short-pulse mode. Conversion to frequency-doubled light is achieved with 60 to 70% efficiency with short pulses and 40 to 50% efficiency with long pulses. Experiments with the seventh planar-target beam and the six-beam system can be run concurrently with different wavelengths and pulse durations.

Planar-target experiments have been carried out to determine target-coupling and thermal smoothing as a function of laser irradiance and wavelength. From Newton's Second Law, the achievable fuel acceleration is proportional to the rate at which the ablator mass is blown away. The laser energy tends to deposit near the critical density, (that for which the electron-plasma frequency is the same as the laser frequency). As this density increases with laser frequency, heating at higher density (with greater mass ablation) is anticipated for shorter wavelength radiation. The ablation rate was measured by depositing a thin layer of one material onto a thick substrate of another material and irradiating the thin material (B. Yaakobi, et.al., Optics Comm 39, p175, 1981). Time-resolved observations of characteristic X-radiation from the first material provided the time required to ablate it away. Results demonstrated higher ablation rates at lower wavelength.

The effects of thermal smoothing in planar targets were investigated by masking the focusing lens with a neutral-density filter to provide a deliberately nonuniform beam (A.J. Cole, et al., Annual Report to the Laser Facility Committee, RL-82-039, pp 4.13-4.17, 1982). The X-ray backlighting technique was used to determine the local target velocity for different portions of the incident beam. Velocity differences between high- and low-intensity regions were found to be less for longer wavelength and higher intensity. As thermal smoothing is due to diffusion of energy from the critical layer to the solid-density regions of the target, better smoothing was anticipated and observed for the larger separation encountered with low critical density (long wavelength) and high intensity (greater expansion of the critical-density regime from the solid portion of the target).

Researchers at Rutherford in collaboration with the University of Bristol have developed a nuclear-track recording technique to analyze α particles emitted by DT fusion in spherical targets. The particles create a trail of chemical damage while traversing a CR-39 plastic. Subsequent immersion of the plastic in NaOH results in preferential etching along the track axis. The depth and diameter of the etch pit can be measured under a microscope to determine the incident energy of ions with about 30 keV resolution. An advantage of this technique is its insensitivity to the electrons, gamma and X-rays encountered in the hostile environments of ICF research.

Recently, the etch-pit recording technique was employed to determine the change in ion stopping power associated with the plasma state. This subject is important to light- and heavy-ion-driven ICF researchers since the rate of slowing of the driving ion beam in the $\approx$200 eV ablation plasma must be known to determine the accelerator and target designs. Mr. William Toner described the experiment in which 4 beams in the short-pulse mode delivered about 40 J to a 100-μm diameter microballoon target containing DT gas. The subsequent implosion and fusion created about 10^6 α particles in a 20-ps pulse. A 3.5 μm-thick Mylar foil, located about 3 mm from the microexplosion, received about 20 J from the other two VULCAN beams in a 100-μm focal spot. The timing of the foil irradiation was such that the 100-eV plasma had expanded to about 10% of solid density at the time of α particle passage. The foil was angled so that the ions traversed a 5-μm path through either the plasma or surrounding cold portion of the Mylar foil. A CR-39 detector was placed 40 mm beyond the foil and recorded tracks for α particles passing through both the hot and cold regions of the foil. Comparison of the etched tracks for the two regions showed a 30% decrease in range for ions passing through the hot plasma. The result is in qualitative agreement with theoretical modeling of ion stopping in plasmas and deuteron-beam experiments carried out at the Naval Research Laboratory in Washington, DC. The Rutherford experimental technique has greater flexibility than that used at NRL because independent control of plasma conditions can be exercised to determine the stopping-power enhancement over a wide plasma-parameter range.

The observed improved coupling with increased frequency suggests the development of lasers that operate at the much shorter wavelengths of the X-ray ultraviolet (XUV) and X-ray regimes. The development of X-ray lasers may also provide applications in many areas outside of ICF. They include X-ray lithography for large-scale integrated circuits, directed-energy weapons in space, atomic physics, molecular chemistry, medical diagnosis, and high-resolution holography and microscopy. Researchers at RAL and Hull University are investigating a laser based on population inversion in highly ionized, laser-heated carbon. Experiments now in progress on VULCAN are designed to recreate results at

Hull that showed gain on the Carbon-VI Balmer α line at 182 Å. The researchers are investigating laser coupling to the carbon plasma, determining the effects of impurities, and observing the nature of carbon-plasma expansion. A cylindrical lens was used to form a line focus on a carbon fiber (typically 3 μm in diameter) delivering 20-40 J in about 80 ps over a 2 to 3-mm length. Calorimetry was used to infer an energy-coupling factor of about 8%. Electron temperatures were measured with X-ray diodes to be 200 to 300 eV, in agreement with hydrodynamic code calculations. In this laser scheme, rapid plasma expansion prevents equilibrium recombination of the plasma as it cools, thereby creating the population inversion for the lasing transition. As yet, gain has not been reported in the RAL experiments.

The OCTAL laser at CEA Limeil consists of eight beam lines for implosion studies with a ninth line dedicated to diagnosis and the production of X-rays for backlighting. A separate 100-J, single-beam Nd-glass laser called P102 is used for planar-target studies. The OCTAL system has recently been upgraded to a total output energy of about 2 kJ in the long-pulse mode using 12-cm-diameter rod amplifiers. The experimental results reported were obtained before the upgrade at power and energy levels comparable to those achieved with VULCAN.

Investigation of the mechanisms responsible for the transfer of energy from the laser-absorbing critical layer in the target blow-off plasma to the solid-density region is of primary importance for laser fusion. The energy conduction associated with both thermal and superthermal electrons must be known so that hydrodynamic codes can adequately be benchmarked against experiments, mass-ablation rates can be determined, and target preheat by fast electrons can be evaluated. Researchers at Limeil have employed planar, layered targets composed of thick glass substrates coated with aluminum 160 Å to 4500 Å thick to perform a detailed study of energy-transport processes (J.C. Couturaud et al., Nuclear Fusion 21, p1657, 1981). Laser pulse durations of 80 ps and flux levels of 10^{14} to 10^{16} W/cm^2 at 1.06 μm produced characteristic resonance-line radiation from hydrogen-like and helium-like aluminum and silicon. Absolute energies for these lines were determined by a flat KAP crystal spectrograph operating in the 1.5 to 3-keV regime. The variations of emitted-line energies with aluminum thickness were then compared with predictions of a 1-D Lagrangian code with empirically adjustable parameters for thermal- and superthermal-electron transport and a time-dependent Corona model for the X-ray line emission. Line opacities were determined from Doppler and Stark broadening. A thermal-flux inhibition factor (due presumably to ion-acoustic turbulence or self-generated magnetic fields) of 3×10^{-2} was inferred from the variation of helium-like silicon line radiation with aluminum thickness. The fast-electron preheat characteristics were determined from the observed front-surface plasma expansion with X-ray pinhole photography and a delayed 2-ω laser pulse to locate the critical surface. Comparison with code calculations yielded $\ell/\eta \cong 10^2$ μm where ℓ was the hot-electron-deposition length in the cold material and η was the ratio of energy carried by the electrons to the absorbed laser energy.

Thermal and fast electron transport also played important roles in spherical-implosion experiments conducted on OCTAL that were designed to study the effects of asymmetric irradiation. The neutron yield from DT-filled microballoons was measured as a function of top-to-bottom asymmetry of irradiation. It was found that neutron yields from targets in which the top-to-bottom ratio was only 0.1 were comparable to those receiving uniform illumination. The results indicate strong energy-flow smoothing leading to near-symmetric implosions. When illumination at the top was completely cut off, the resulting orders-of-magnitude reduction in neutron yield indicated a much poorer quality implosion.

The interesting results of this experiment were explained to the author by Dr. Decroisette, the experimental group leader. The 10% irradiation level is sufficient to produce a highly conductive plasma at the top of the target. Thermal-electron currents driven by temperature and density gradients can then flow. These internal currents create a magnetic field in the coronal plasma that guides superthermal electrons produced at the bottom around to the top. The energy transported to the top by superthermals is sufficient to symmetrize the target implosion. When the top receives no laser illumination, it remains poorly conductive, thereby supressing the thermal-electron flow and the magnetic field.

RAL and CEA Limeil are investigating different means of overcoming the major obstacles to laser-driven ICF outlined above. At RAL, the Gas Laser Development Group has constructed a high-power, electron-beam-excited KrF laser as a test bed for a future fusion-laser system. Operation of this RAL SPRITE laser is described in the preceding article. Such a laser has the potentially attractive features of high efficiency, high energy at moderate cost, and short wavelength. Research at Limeil is now devoted to the use of classified target designs to overcome problems of target coupling, fast-electron preheat, and sensitivity to asymmetries. In these designs, the laser radiation produces thermal, plasma X-radiation outside the fuel capsule that is then absorbed by the capsule to drive the implosion. The upgraded OCTAL is now configured to drive classified targets with two-sided irradiation in preparation for Limeil's next laser facility. In about 4 years, CEA Limeil will receive two NOVA chains from the Lawrence Livermore National Laboratory. This system, dubbed PHEBOS, will produce 20 kJ of 1.06-μm radiation in 1 ns with a planned

capability of 0.2 to 5 ns and conversion to 2ω and 3ω operation. Dr. Claude Patou, in charge of PHEBOS construction, hopes that the break-even point (fusion energy out = laser energy in) will then be achieved.

D. Mosher

ONR London

NEWS & NOTES

A EURO—MIT?

The economy and politics of western Europe are affected directly or indirectly by developments in the United States. Thus, the persistence of high interest rates in the US has produced a great strengthening of the dollar in international monetary exchange (American tourists can almost afford Paris hotels and restaurants again) and the prevailing US recession has produced its counterparts throughout western Europe, and beyond. To be able to compete on more equal terms with the US and other nations such as the USSR and Japan, European nations have advantageously combined resources and shared costs in certain collective enterprises. The most successful venture of this sort, of course, is the European Economic Community (the so-called Common Market). Another collective venture is the European Space Agency with 11 member nations and a distinguished record of accomplishment.

The latest suggestion for a shared effort is the formation of a European institute of science and technology. Discussions at this point are only preliminary but the goal would be to create a "European MIT." Those familiar with the Massachusetts Institute of Technology may be bemused by the immensity of the task. The goal may not be impossible to achieve, but financial resources and common commitment—even if sustained—would hardly be guarantors of success. Most likely an evolutionary process over a long period of time will be required where transitional stages may be prompted by wise administration and ample motivation.

MIT has assembled a truly distinguished record that certainly inspires mimicry, however difficult that may be to achieve. MIT is a private institution with substantial endowment, a very large operating budget that in large measure derives from government support of basic and applied research, a strong and continuing commitment to teaching excellence especially at the undergraduate level, and an excellent physical plant far more splendid for its utility than esthetics. Except for certain laboratories under its auspices, the complete university is located on one compact campus adjacent to the Charles River in Cambridge, Massachusetts, from where preferred views of Boston are available. MIT facility and research staff members have a long and successful relationship with industry, particularly, in innovative and high technology initiatives. For example, MIT people have played an important role in the development of the microelectronics industry and x-ray camera techniques used in astrophysical observations. Only recently, the institute received an industrial grant of $8.5M to promote basic research in microbiology in areas including cloning and gene splicing.

This scenario has strong contrast with current ideas for the proposed European counterpart. The latter would consist of small campuses spread over at least 10 sites, each accommodating about 2,000 to 3,000 students. The faculty would be drawn from all countries, and the curriculum would be standardized among the campuses. Funding would be drawn from the host country, the Common Market, and private industry. Industrial funding would be solicited, in particular, from multinational corporations and would be used for research to equalize the European position against its competitors in areas such as the next generation computer and biotechnology.

R.L. Carovillano

ONR London

FRANCE BOOSTS ELECTRONICS R&D

Apparently determined to provide a long-term solution to its growing balance-of-trade deficit, the French Government announced on July 27 a 5-year program costing 140 billion francs ($20 billion) to bolster the electronics industry. Although not as massive in scope as was the French program of the 1970s designed to bolster the nuclear program by 220 billion francs ($31 billion) or the 160-billion-franc ($22+ billion) telecommunications modernization, the amount is nevertheless both significant and surprising. When considered in conjunction with the newly developing austerity program and its drastic cuts in price expenditures, the recent wage and price freezes, and the two devaluations of the franc, the electronics boost could not have been anticipated without benefit of much well-thought-out study. Minister for Industry and Technology Research Jean-Pierre Chevenement expects this shot-in-the-arm "will add 80,000 to the workforce." Whether or not the 80,000 jobs are in addition to the additional 54,000 public-sector jobs Prime Minister Pierre Mauroy promised last year is not known. Even then the combination would represent but a small part of the 2 million French currently unemployed. Included in the 80,000 are 7,000 electronics engineers and technicians.

The augmentation earmarks 10 billion francs this year for state-owned industries and 2.3 billion francs for others. The projects to be covered include very large scale integrated

circuits (VLSI), basic modules for mini- and microcomputers, computer-assisted instruction (CAI) and translation, computer-assisted design (CID), and software engineering. This shot-in-the-arm could well far surpass the US DoD very high speed integrated circuit (VHSIC) program in aiding the silicon-based microelectronics industry. A study group is to be organized to work out the details and implement the project.

M.N. Yoder

ONR London

FUNDING SUPPORT WITHDRAWN

The US and UK have both apparently decided to terminate their financial support of the International Institute of Applied Systems Analysis (IIASA), located in Laxenburg (near Vienna), Austria. IIASA was established as a nongovernmental multidisciplinary institute; certainly many Western scientists approved its dedication to "tackling the complex problems facing mankind today, problems that are the consequence of the success of modern science and technology and that now require the joint efforts of East and West in order to find approaches adequate to the challenge of the future." Recent IIASA research projects having international impact have concerned energy systems and food supplies. (See ESN 36-4:86 [1982] for more details on a specific example.)

The institute opened in 1972, under the direction of Howard Raiffa and with the support of about a dozen nations from both the East and the West. Prominent US scientists in the OR/SA areas who have contributed to the efforts at IIASA have included Ralph Keeney, Detlof Von Winterfeldt, Edward Quade, Hugh Miser (currently serving as executive editor at IIASA), and many others. There are about 90 scientists currently working at IIASA. Prior to the withdrawal of the US and UK support, IIASA had an annual budget of about $10 million, with about half of that coming in roughly equal amounts from the US and USSR. With the loss of US funding on 1 October, 1982, several projects at IIASA will be terminated, and the future of the institute is in considerable doubt. The western systems-analysis community will certainly regret the reduced opportunities for joint East-West research work.

D.R. Barr

ONR London

ELECTRONIC CONTRACTS

When contracts are accepted now, the participating parties usually have to go to the same place for signing, or they have to use a "trusted intermediary" such as a postman or legal agent. Prof. Michael Rabin of the Hebrew University Institute of Mathematics has recently explored the possibility that electronic contract agreement can be an important part of electronic mail. Everybody would carry on his or her person a small pocket-size device, by means of which identity could be electronically validated. The signals between the two or more persons could be exchanged for a contract agreement at a distance. Certified electronic mail could be handled in the same way, with an electronic receipt. Rabin proposes a public-private encryption system with many subscribers. Each member of the system could have two encryption keys, one that was public and one that was private and secret. The system would send out a public key whose pattern was not known in advance. The two parties would then agree to send over their secret signatures incrementally, with the two parties alternating. If the two parties followed the defined protocol for a certain time, say 5 minutes, then receipt of a properly decrypted signature at each end would constitute a binding agreement.

G.M. Sokol

US Army Research Development, and Standardization Group, London

A MULTILANGUAGE KEYBOARD

For international offices, each language may impose its own requirements on office hardware and software systems. Unless steps are taken, there is an inevitable proliferation of additional symbols; sometimes 60 to 100 special nonalphanumeric keys are found on a keyboard, causing much difficulty to the typists, editors, and others who have to deal with the system.

Under EEC-Brussels sponsorship, K.P. Fähnrich and P. Kern of the Fraunhofer Institute (Stuttgart, West Germany) have just completed a study of three new keyboard proposals. The keyboards were designed to different requirements for differing shift levels and extra-diacritic keys; also, a mnemonic principle was studied for coding difficult symbols.

An extensive test trial was held recently at EEC-Brussels, with about 2.5 million keystrokes being recorded. It is expected that an "intelligent keyboard" based on this research will be available soon. The keyboard will be soft or flexible, and will permit all of the 340 TELETEX symbols to be entered.

N.A. Bond, Jr.

ONR London

DETECTION OF WEAR DEBRIS IN LUBRICATION FLUIDS

A novel type of sensor, for detecting the presence of wear or contaminant particles in lubricating fluids, is being developed at the Fulmer Research Laboratories (UK). The sensor consists of a thin resistive metal film deposited onto a ceramic substrate. When a stream of fluid containing abrasive particles is directed against the metal film, it is abraded and thus its electrical resistance is increased. This allows abrasive debris present in the fluid to be detected. Significantly, this monitoring occurs in real time, in contrast with various oil analysis schemes based on laboratory analysis of fluid samples.

An example application of this detector could be in monitoring lubricating oil in a mechanical system, such as a helicopter gear box. A small stream of oil could be tapped directly off of the pressure lubricating system of the gear box and returned to the oil sump after passing the detector. An alarm could be initiated any time the rate of change of resistance became sufficiently high. In addition to this type of application as a contamination detector, the sensor could be applied to studies of the break-in of new engines, determination of harmful impurities in hydraulic systems, measuring the effectiveness of fluid filters, and detection of impurities in batches of engine fuel. A variation of the sensor has been used at Fulmer to measure the abrasiveness of batches of computer tape and audio tape.

D.R. Barr

ONR London

A MINE OF METALS INFORMATION IN LONDON

The Metals Society was created in 1974 by an Act of Parliament joining the two broad divisions of ferrous metallurgy and nonferrous metallurgy covered by the historic Iron and Steel Institute, founded in 1869, and the Institute of Metals, founded in 1908. The headquarters and library of the resultant Metals Society are housed in quarters in central London at No. 1 Carlton House Terrace, London SW1Y 5DB, telephone 01-839-4071. The headquarters and library overlook The Mall.

The library gives any stateside engineer or scientist an opportunity of testing the extent of information exchange and its availability between the US and the UK while simultaneously breathing a bit of history in the environs of the British Empire. The library is essentially one large attractive room encased with books on the second floor of Carlton House above an impressive foyer. Portraits of persons such as Andrew Carnegie and Edward Williams, President of The Iron and Steel Institute in 1879, grace the walls. One feels the history here while reading, for example, from the 1887 presidential address by Daniel Adamson that the "application of mild steel, possessing a tensile strain of about 30 tons both in its longitudinal and circumferential direction, is a great gain upon the older or Armstrong system of constructing heavy artillery with welded wrought iron coils, possessing a strength of 22 tons circumferentially, and only 12 tons longitudinally." There is some confusion of terms here, but the message hopefully is made clear. . .the library seems to live up fully to its motto: WE ARE A MINE OF INFORMATION.

A corner of the Metals Society Library with Wendy Todd (librarian) seated. Carol Moore (Search Services Manager) beside desk, and Heather Williams (Search Services Assistant) helping a visitor.

The society has continued the work of its predecessors by forming a cooperative body with its kindred organizations both at home and overseas. Over one third of the society's membership comes from outside the United Kingdom. Members of the American Society for Metals are encouraged to use the extensive library holdings. The society is open only to individuals as no company or group membership is available. The purpose of the society is to promote all aspects of the science and technology of metals, alloys, and allied materials by way of organizing meetings to provide an international forum for exchange of knowledge and for discussions, publishing items, providing information and library services, and promoting member participation in activities through an awards granting process.

The society publishes a number of periodicals: Metals Society World, Metal Science, Metals Technology, International Metals Reviews, Ironmaking and Steelmaking, British Corrosion Journal, Powder Metallurgy, and Steel in the USSR. The library also distributes a useful monthly accessions list entitled International Metals Publications. In

addition, the world's most comprehensive range of information services available on metals and metals industries is provided by METALS INFORMATION publications, a joint activity of the Metals Society and the American Society for Metals. METALS INFORMATION publishes Metals Abstracts, Metals Abstracts Index, and Alloys Index, all of which are found in the society's library. METALS INFORMATION also maintains the world's most complete metals data base, METADEX. METADEX comprises over 500,000 computer searchable records covering technical papers, 1,200 journals, papers of international metals conferences, and technical book literature.

A library visitor browses through the journals.

The director of the Metals Society is Sir Geoffrey Ford. The secretary at headquarters is Robert B. Wood and the library is under the direction of Miss Wendy Todd, librarian. She heads a very helpful staff that is available to assist in sorting out such items as the spelling of aluminium or, more seriously, the finding of all kinds of technical metals information. (ASM and Metals Society members will know that the publication of a METADEX Term Frequency Record was announced in the August ASM News. The record will provide rapid "look-up" knowledge of documents posted to any index term, reducing on-line time and cost and allowing users to construct search records in advance of actual terminal use.)

R.W. Armstrong

D.L. Mott

ONR London

POLYMER SCIENCE IN EUROPE AND ELSEWHERE

An analysis of the contributions to the 28th Macromolecular Symposium of the International Union of Pure and Applied Chemistry held in Amherst, Massachusetts, from 12 to 16 July 1982 leads to an interesting, if approximate, insight into the relative levels of polymer research outside of the US. This meeting was particularly useful for analysis as nearly 1,000 papers were given. Almost all known experts were personally invited and only abstracts were needed. Naturally a huge preponderance of papers were from the US itself (but only 22 from Canada), and there were 90 from Japan. France and Western Germany had the largest number of European contributors, 62 and 61 respectively, followed by the UK with 35. Italy had 24, Belgium 16, followed by Israel and Holland. All other countries had 6 or less. Although financial considerations were undoubtedly also involved, it is believed that this simple analysis does accurately reflect the relative volumes of basic polymer research in the western world.

V.T. Stannett

ONR London

ONRL STAFF CHANGES

In August we welcomed aboard liasion scientist Dr. Jacob F. Blackburn. Dr. Blackburn is a mathematician and computer scientist. He came to ONR London from the State Department. Most recently, he was on assignment to the National Academy of Sciences as executive director of the Computer Science and Technology Board.